ASD-TR-77-6 Vol. II

AN EXTENDED PREDICTION MODEL FOR AIRPLANE BRAKING DISTANCE AND A SPECIFICATION FOR A TOTAL BRAKING PREDICTION SYSTEM

Volume II

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AERONAUTICAL SYSTEMS DIVISION
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Wright-Patterson Air Force Base, Ohio 45433

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This report details the results from the sensitivity study portion of the Combat Traction II, Phase II (Extended) Program and also contains the calculations resulting from prediction equation formulation for the B-52, KC-135 and F-111 airplanes. The objectives, results and recommendations of this effort are contained in ASD Technical Report ASD-TR-77-6, Volume I.

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PREFACE

This report was prepared by M. K. Wahi, S. M. Warren, and H. H. Straub of the Boeing Commercial Airplane Company under a USAF Contract F33657-74-C-0129 (extended). The program was divided into three tasks. Task I involved the formulation of a tire correlation model, a test outline to validate the model, establishment of a friction prediction subsystem specification criteria and evaluation of existing ground vehicles. The work completed under Task I of this contract was performed from May 1975 to December 1975 and all aspects of that work are described in a separate report, ASD-TR-77-7.

Task II involved a sensitivity analysis of airplane braking distance by using the Boeing Brake Control Simulator for the USAF B-52, KC-135 and F-111 airplanes to validate the general prediction model developed in the previously contracted effort. Task III objectives were to establish compatibility between Task II and Task I subsystems and to recommend a test program to verify the effectiveness and reliability of this Total Braking Prediction System (TBPS). The present volume I of this report describes the hardware and antiskid systems used on the brake control simulator as well as the test conditions and parameters used in developing data required for the dimensional analysis. The work described herein was performed from August 1975 to December 1976.

The authors are indebted to Messers N. S. Attri. and A. J. P. Lloyd for their guidance and technical contribution as respective program managers at various stages of the contract.

The authors are also indebted to Messers W. B. Tracy ASD/ENFEM, D. B. Tremblay ASD/ENFE, Lt. Col. R. Kennah, ASD/AEAA and Maj. R. Cauley, AFCEC/EMR of the USAF for their program support.

TABLE OF CONTENTS

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TABLE OF CONTENTS (Concluded)

Page

LIST OF TABLES

LIST OF TABLES (Concluded)

LIST OF ILLUSTRATIONS

SECTION I
INTRODUCTION

This volume describes the hardware and antiskid systems used on the brake control simulator plus the test conditions and parameters used in developing data for the dimensional analysis in the study.

SECTION II
BASIC BRAKE CONTROL HYDRAULIC SYSTEM

The hydraulic portion of the brake control simulator employed standard aircraft hydraulic system components. The actual hydraulic configuration of each of the three aircraft was mocked up. The major components common to most of the aircraft braking system are:

- Antiskid valve
- Pilot metering valve
- Brakes
- Accumulator
- Tubing

To generate the proper hydraulic system response, line lengths and diameters, valve locations, and restrictions were implemented as specified by the technical documents for each airplane. The brake hydraulic system of each aircraft is activated by a pilot input to the pilot metering valve. As the pilot applies force to the brake pedals pressure is metered to the antiskid valve and brake.

The main function of the antiskid valve is to modulate the brake pressure based on an electrical signal from a control box. To maintain the proper pressure and flow characteristics through the antiskid valve and pilot metering valve, actual aircraft brakes were used. This ensured that the correct pressure-volume relationship existed during system operation. Because the system pressure is modulated by the antiskid valve, large demands can be placed on the hydraulic supply. To partially eliminate the resulting supply pressure fluctuations, an accumulator is placed in the system supply line.

SECTION III
B-52H BRAKE CONTROL SYSTEM DESCRIPTION AND SYSTEM CHARACTERISTICS

The B-52 Brake Control System consists of skid and locked wheel detectors, control shields, a hydraulic system and brakes. The control system is designed to automatically release and reapply the brakes in response to signals generated by the detector and control shield.

The hydraulic system mockup used in the B-52 sensitivity tests is shown in Figure 1. The mockup represents one quarter of a B-52's brake system. Each of the four systems has its own hydraulic supply and control shield. Each system operates independently, but all are actuated by a single pilot command. Figure 2 is a system schematic identifying the mockup components. Table 1, in conjunction with Figure 2, defines the significant hydraulic system information. Table 2 details the specific hardware used in the mockup.

1. SYSTEM DESCRIPTION

A. ANTISKID CONTROL SYSTEM

The B-52 Mark I antiskid control system consists of three components; the skid and locked wheel detector, the control shield, and the solenoid valve. The detector is an electro-mechanical device, providing logic signals to the control shield. The shield is a power conditioner containing a series of relays. The relays interpret the logic signals from the detector and apply an electrical signal to the hydraulic solenoid valve, to dump or apply metered brake pressure.

The detector shown in Figure 3 is the heart of the antiskid system. Its function in the system is to signal wheel decelerations above a preset value. The device is mounted in the axle and is driven by wheel hubcap rotation. The skid sensing portion of the detector consists of an inertia flywheel and an overload-release clutch. When wheel deceleration exceeds a predetermined rate, the flywheel's inertia causes the springloaded clutch to release. The overload torque decelerates the flywheel at a rate which is much smaller than the wheel lock-up deceleration rate. This causes a set of electrical points to move into contact, thereby completing the skid circuit to the control shield. The shield in turn provides an electrical signal to the antiskid solenoid valve resulting in a release of brake pressure.

As the wheel accelerates back to synchronous speed, the contacts in the detector open, removing the signal from the antiskid solenoid valve. Thus, the pilot's metered pressure is again applied to the brake, allowing the skid cycle to repeat.

The antiskid control system, as described above, is represented by the functional block diagram of Figure 4.

The second function of the detector is to provide locked-wheel protection for the paired wheel in a lock-wheel set. A commutating switch simply senses the existence of wheel speed. This switch allows completion of the skid circuit during a locked-wheel condition.

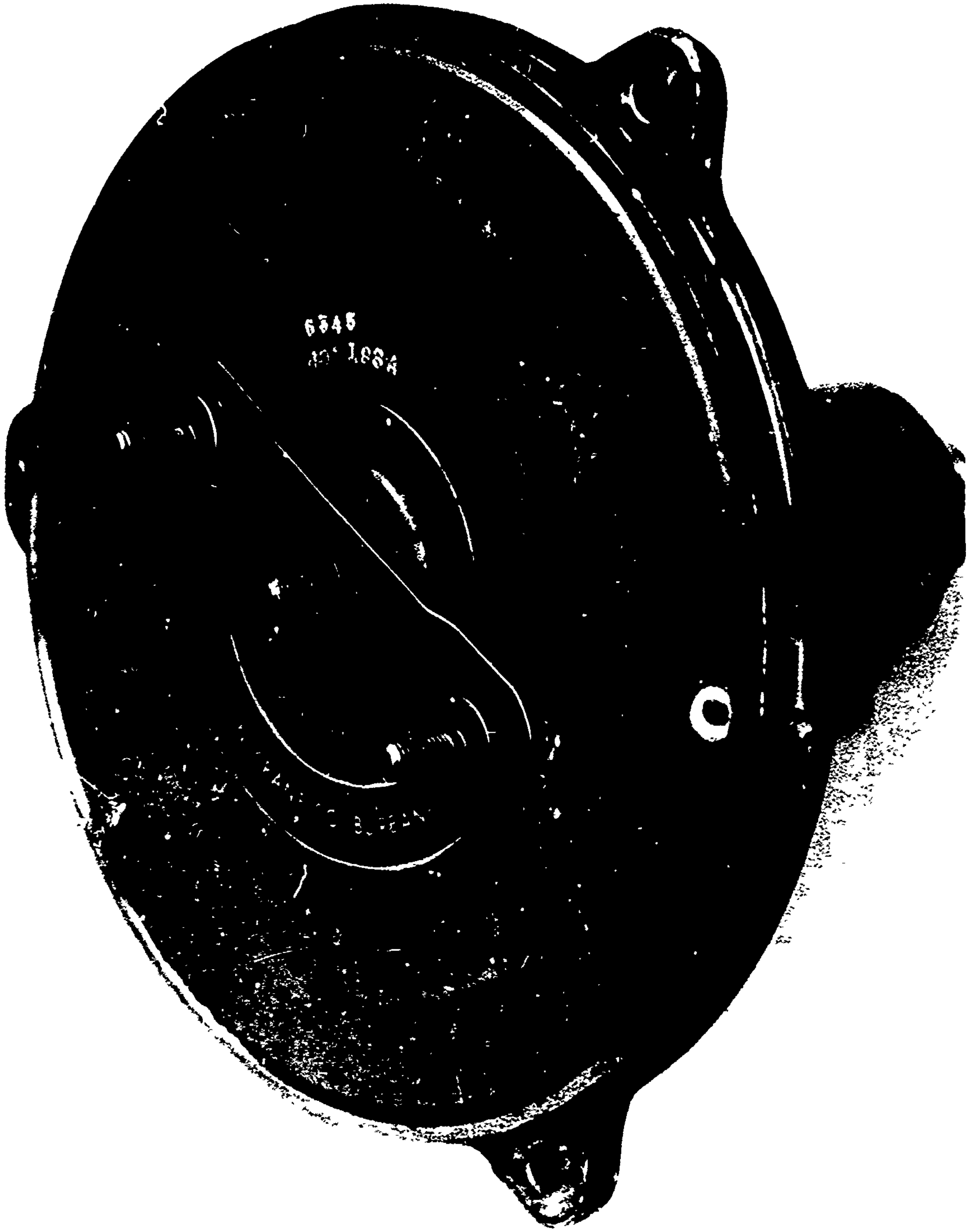

Figure 1.—B-52H Brake Hydraulic System Mockup

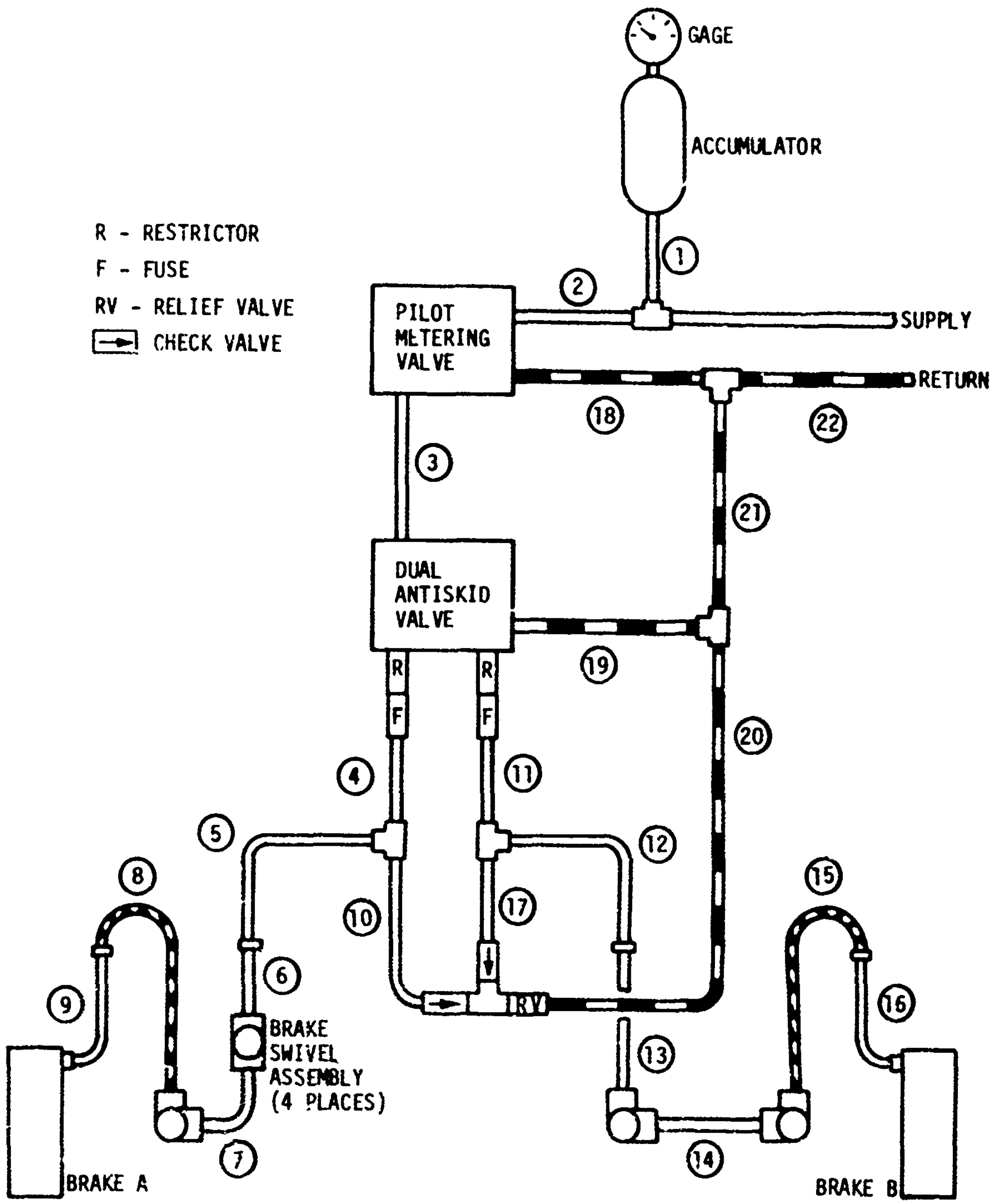

Figure 2.—B-52H Brake Hydraulic System Schematic

Table 1.—B-52H Brake Hydraulic System Mockup

DESCRIPTION	LINE NUMBER	LINE SIZE	LINE LENGTH (INCHES)
ACCUMULATOR LINE	1	8S35	21
SUPPLY LINE	2	8S35	17
METERED PRESSURE LINE	3	8A35	92
A-BRAKE PRESSURE LINE	4	6A35	10
	5	6A35	24
	6	6S28	30
	7	8S35	13.5
	8	3/8" Hose	50
	9	6S28	21
A-RELIEF PRESSURE LINE	10	6A35	15
B-BRAKE PRESSURE LINE	11	6A35	10
	12	6A35	14
	13	6S28	29
	14	8S35	13.5
	15	3/8" Hose	50
	16	6535	17
B-RELIEF PRESSURE LINE	17	6A35	22
METERED PRESSURE RETURN LINE	18	8A35	As necessary
BRAKE PRESSURE RETURN LINE	19	6A35	
RELIEF PRESSURE RETURN LINE	20	8A35	
COMMON PRESSURE RETURN LINE	21	8A35	
COMMON PRESSURE RETURN LINE	22	8A35	

Table 2.—B-52H Brake Hydraulic System Mockup Components

ITEM	NATIONAL STOCK NUMBER	QUANTITY
CONTROL SHIELD	1630-00-621-0657	1
SKID AND LOCKED WHEEL DETECTOR	1630-00-650-0788	1
PILOT METERING VALVE (MECHANICAL ACTUATION)	1650-00-332-5721LE	1
DUAL ANTISKID VALVE	1630-00-620-4452	1
RESTRICTOR		1
FUSE	1650-00-839-7856	2
CHECK VALVE	4820-00-698-3314	2
RELIEF VALVE	4820-00-529-4180	1
BRAKE SWIVEL ASSEMBLY	1650-00-306-9778	2
ACCUMULATOR	1650-00-898-9839	1
BRAKE ASSEMBLY	1630-00-777-6698	2

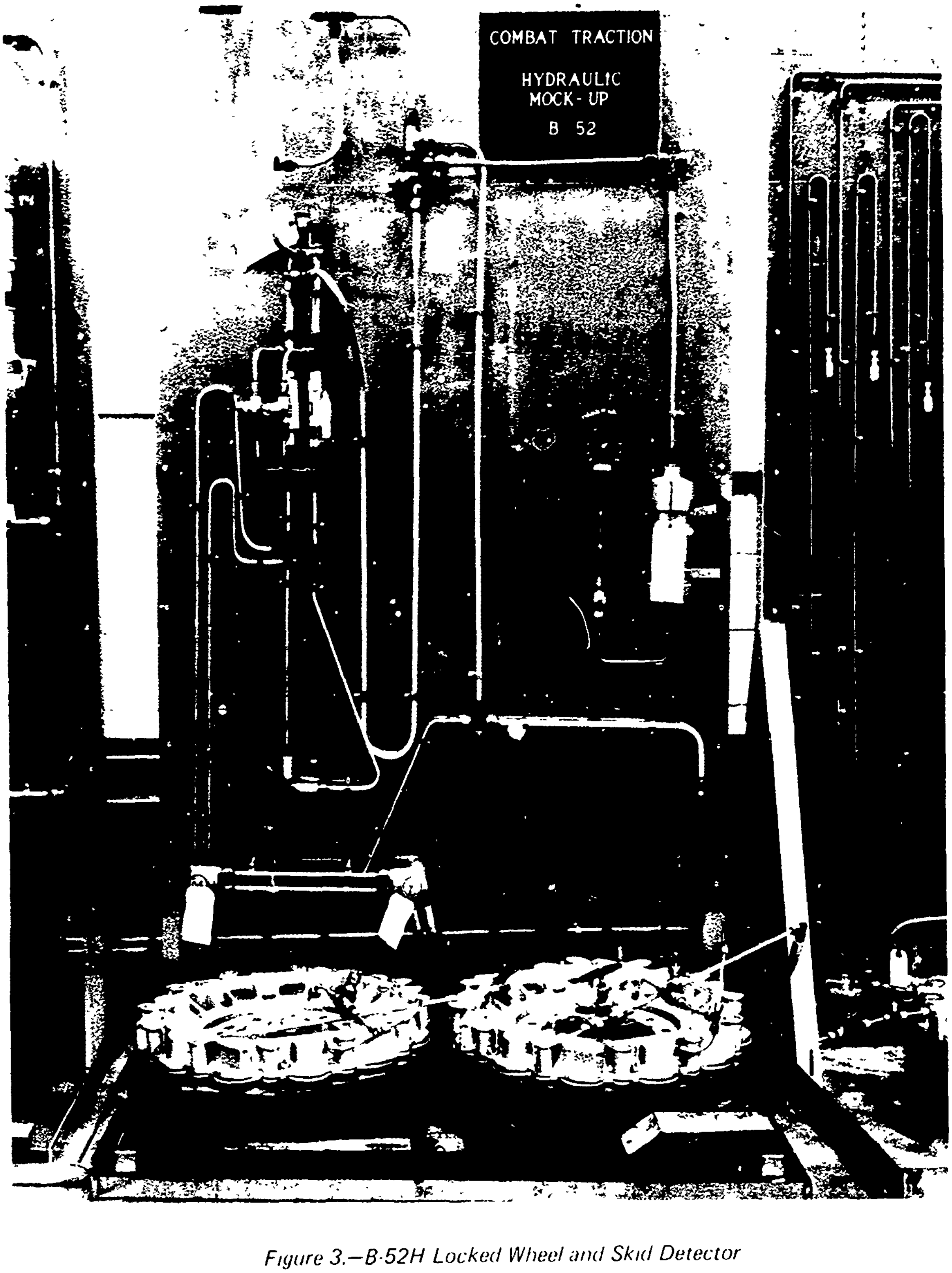

Figure 3.—B-52H Locked Wheel and Skid Detector

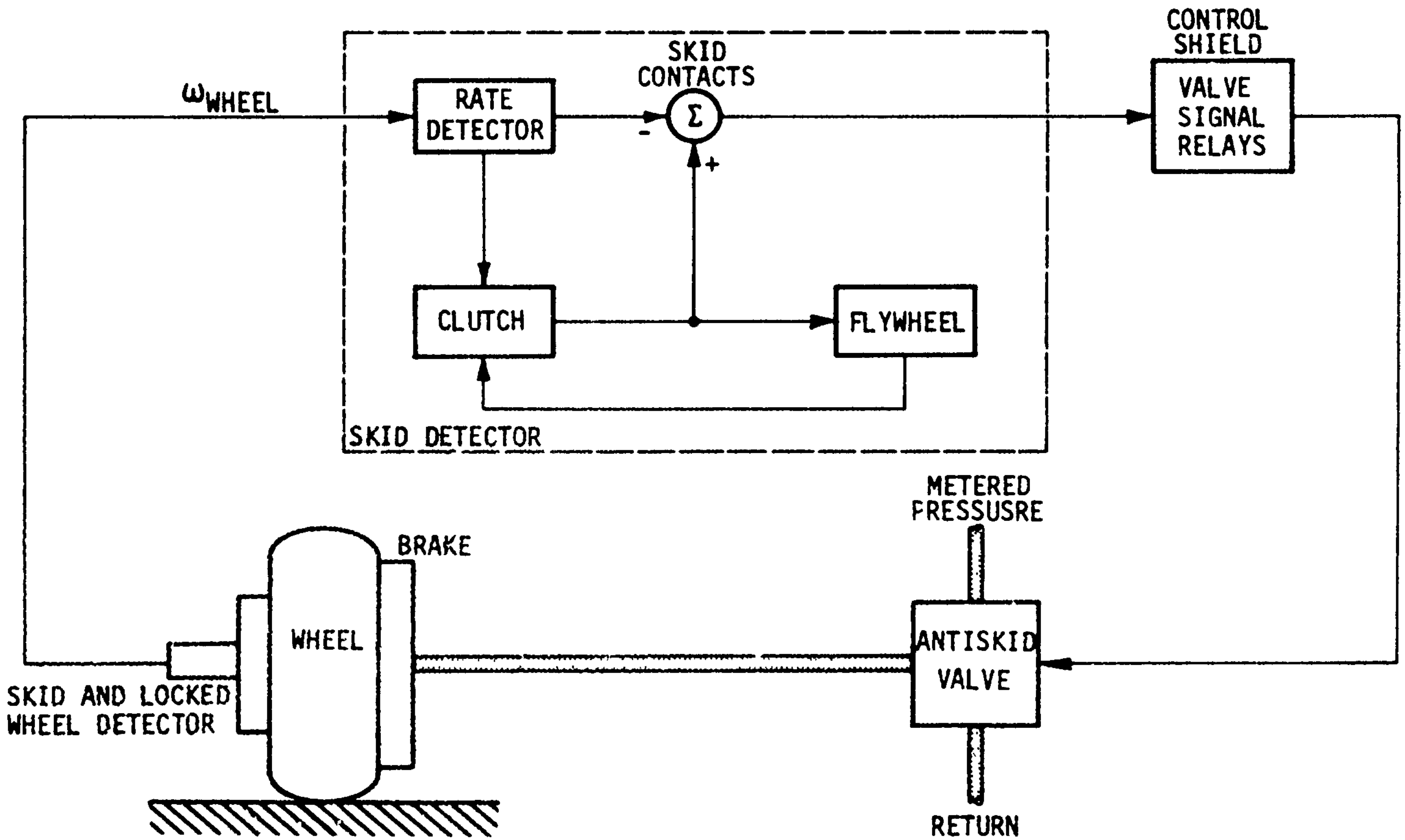

Figure 4.—B-52H Antiskid System Block Diagram

B. LOCKED-WHEEL AND TOUCHDOWN PROTECTION

The two wheels of each gear are connected as a pair to provide locked-wheel protection. The locked-wheel protection is activated when one wheel of a pair reaches a velocity of at least 30 rpm. A locked-wheel signal is provided when one wheel of the pair locks or fails to spin-up. The rotating wheel then supplies a brake release signal, allowing the wheel to spin-up to synchronous speed. However, should both wheels of a locked wheel pair stop rotating no protection is provided.

Touchdown protection is provided by squat switch logic In the air the switch is closed completing a skid circuit resulting in a brake release signal to the antiskid valve.

C. BRAKE HYDRAULIC SYSTEM

The B-52 brake hydraulic system is composed of four simular subsystems. Each subsystem supplys the two brakes on a gear with brake pressure. The description to follow is typical of each subsystem, however, differences are also explained.

Each hydraulic subsystem consists of a pilot metering valve, a dual antiskid (solenoid) valve, an accumulator, restrictors, fuses and the associated tubing. Hydraulic pressure at 3000 psi enters the pilot metering valve. The valve designed to control pressure, meters hydraulic pressure to the antiskid valve in direct proportion to the force applied to the valve. The input force is controlled by the pilot. The two forward metering valves are mechanically actuated by a cable and linkage arrangement from the flight deck. The two aft metering valves are hydraulically slaved to the left forward metering valve.

The output pressure of the metering valves is limited to 700psi by restricting the input force. Pressure from the metering valve enters a dual antiskid valve and is ultimately routed to the brakes through a restrictor and fuse.

The B-52 antiskid valve is an electrically operated solenoid valve. Its function in the brake system is to modulate brake pressure. The valve is spring loaded and biased open to supply pressure in the unenergized state In this condition the brake is pressurized. When energized by by a skid signal the supply to brake port is closed and the brake to return port is opened. In this condition, brake pressure is reduced to return pressure resulting in a brake release.

The accumulator located on the supply pressure side of the pilot metering valve serves a dual purpose in the system. First, it helps to maintain pressure at a constant level by absorbing fluctuations in supply pressure. The accumulator also allows limited brake application in the event of a hydraulic supply system failure.

D. BRAKES

The B-52 brake is a multiple disc design with 4 rotors. The brakes used during this study were overhauled Bendix units.

2. BRAKING SYSTEM CHARACTERISTICS

Preliminary to the sensitivity study, various system and component characteristics were measured. The dynamic response of the B-52 brake hydraulic system is shown in Figure 5. This figure is a representative step response curve for the system. At time equal zero, a step change in brake pressure is commanded, the time history of brake pressure is then recorded. The signal for step response was applied to the antiskid valve while the maximum pressure level was controlled with the metering valve. A compilation of the step response data is shown in Table 3.

Due to the on-off characteristic of the B-52 antiskid valve, frequency response and pressure-current characteristics were not run.

The pressure-volume characteristic of the standard B-52 brake is shown in Figure 6.

3. SIMULATION AND TESTING OF B-52 SKID DETECTOR

The B-52 Mark I skid and locked-wheel detector is an active dynamic component in the antiskid system with time dependent behavior. This required that its operational characteristics be included to assure proper antiskid system performance. Equipment and instrumentation restrictions dictated that the detector be simulated on an analog computer.

The detector provides the brake control system with a signal which results in step changes in commanded brake pressure. The inherent delay times and duration of the pressure command are unique characteristics of the device and must be duplicated for proper brake control system response.

The skid detector is shown schematically in Figure 7. The major components simulated are a rotor, clutch and flywheel. The rotor is mechanically connected to the wheel-tire assembly, and provides the input to which the clutch and flywheel react. A spring connecting the rotor and clutch acts to center the clutch during synchronous operation. The clutch and rotor can rotate relative to one another until the rotor impacts a clutch travel limit which is simulated with a stiff spring.

During synchronous operation, the rotor, clutch and flywheel all rotate at the same speed. At the initiation of a skid the rotor angular velocity decreases, resulting in relative motion between rotor and clutch until the travel limit is impacted. Then the inertia forces of the flywheel overload the clutch and cause the flywheel to slip around the clutch. This slipping action is an indication of a continuing skid, holding the electrical contacts closed. When the wheel recovers from the skid, the rotor speeds up, causing relative motion between rotor and clutch, opening the electrical contacts. As the opposite travel stop is impacted, the clutch is forced to move with the rotor, causing an overload in the opposite direction, until the flywheel speed matches that of the rotor.

A block diagram of the skid detector is shown in Figure 8 and defines the skid detector's dynamic characteristics. The values of the parameters used in the skid detector simulation were determined from engineering drawings of the device and laboratory test results and are shown in Table 4.

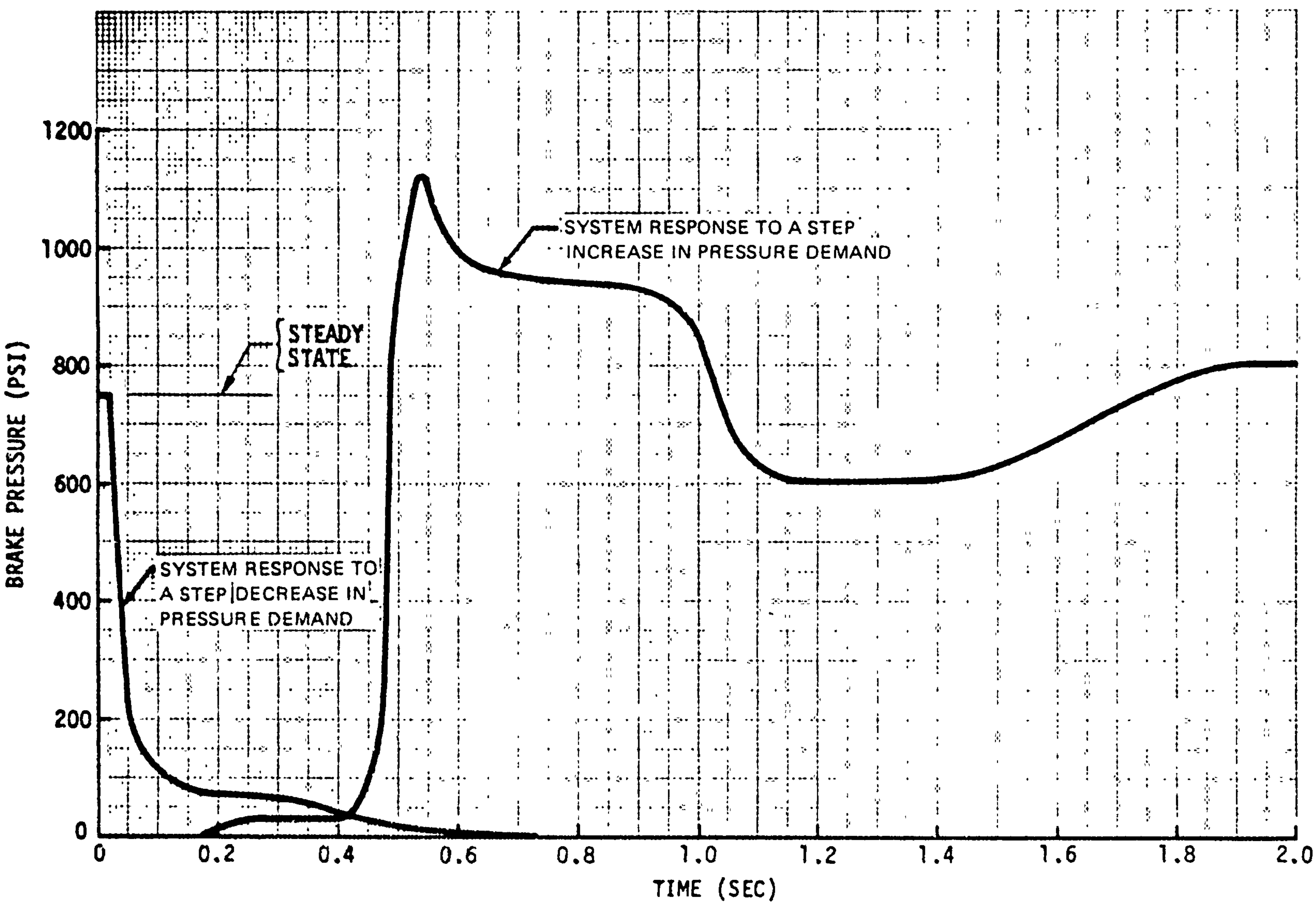

Figure 5.—B-52 Brake Hydraulic System Step Response

Table 3.—B-52H Step Response Data

(Dynamic Response of Left Brake)

TEST CONDITION	METERED PRESSURE (psi)	DELAY RESPONSE TIME (SEC)		RESPONSE TIME TO 80% OF PRESSURE CHANGE (SEC)		PERCENT PRESSURE OVERSHOOT OF STEP CHANGE	
		PRESSURE INCREASE	PRESSURE DECREASE	PRESSURE INCREASE	PRESSURE DECREASE	PRESSURE INCREASE	PRESSURE DECREASE
STANDARD HYDRAULIC CONFIGURATION		(Time to 150 psi)			(Time to 150 psi)		
LEFT SOLENOID (ALONE)	750 to 780	.46	.020	.565	.070	49.0	---
	600 to 630	.485	.020	.52	.075	56.9	---
	350 to 380	.730	.020	.76	.070	78.9	---
LEFT & RIGHT SOLENOIDS (TOGETHER)	750 to 780	.52	.025	.56	.145	90.2	---
	600 to 630	.59	.020	.63	.135	89.0	---
	350 to 380	.915	.030	.945	.130	132.9	---

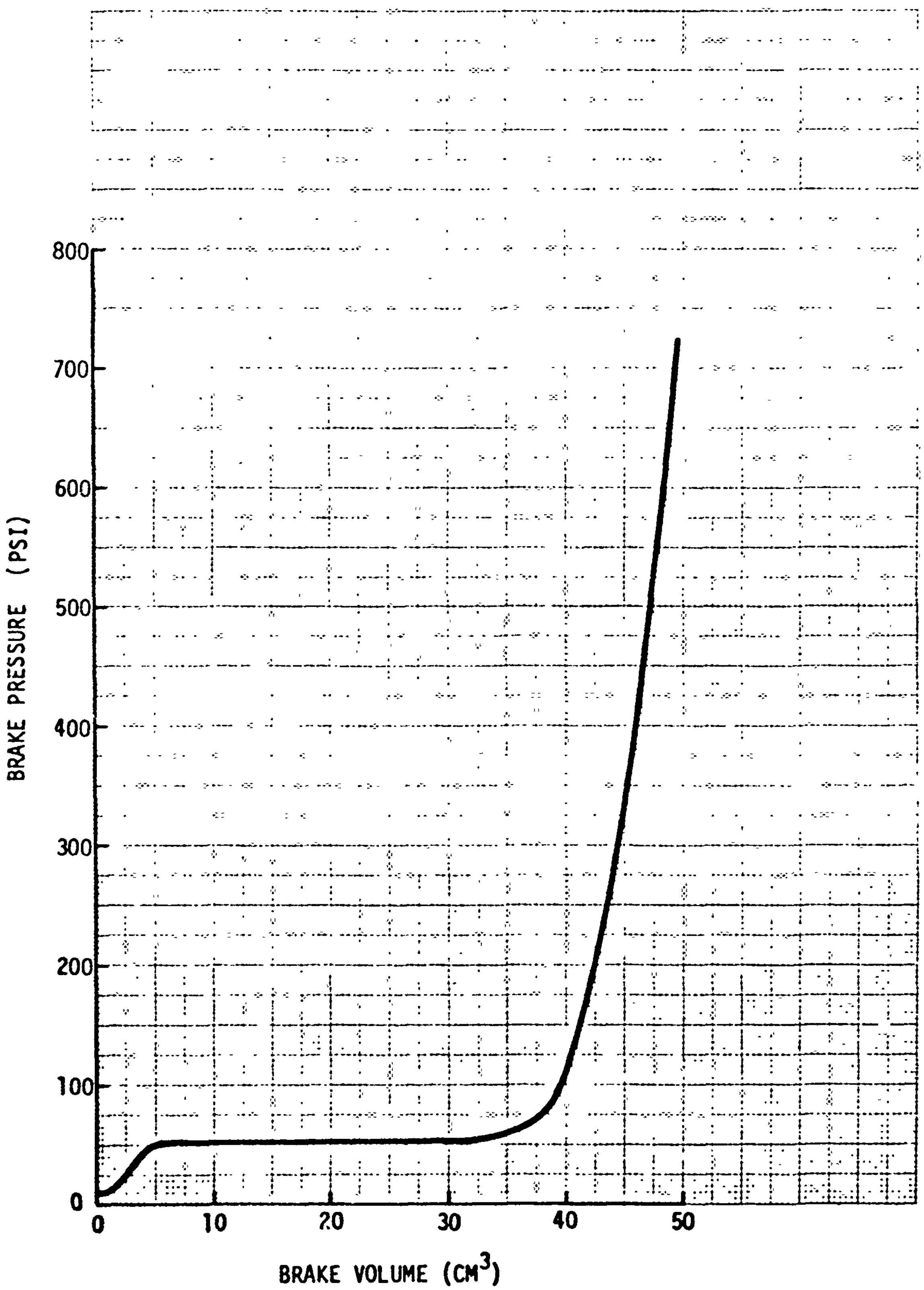

Figure 6.—B-52H Brake Pressure - Volume Characteristic

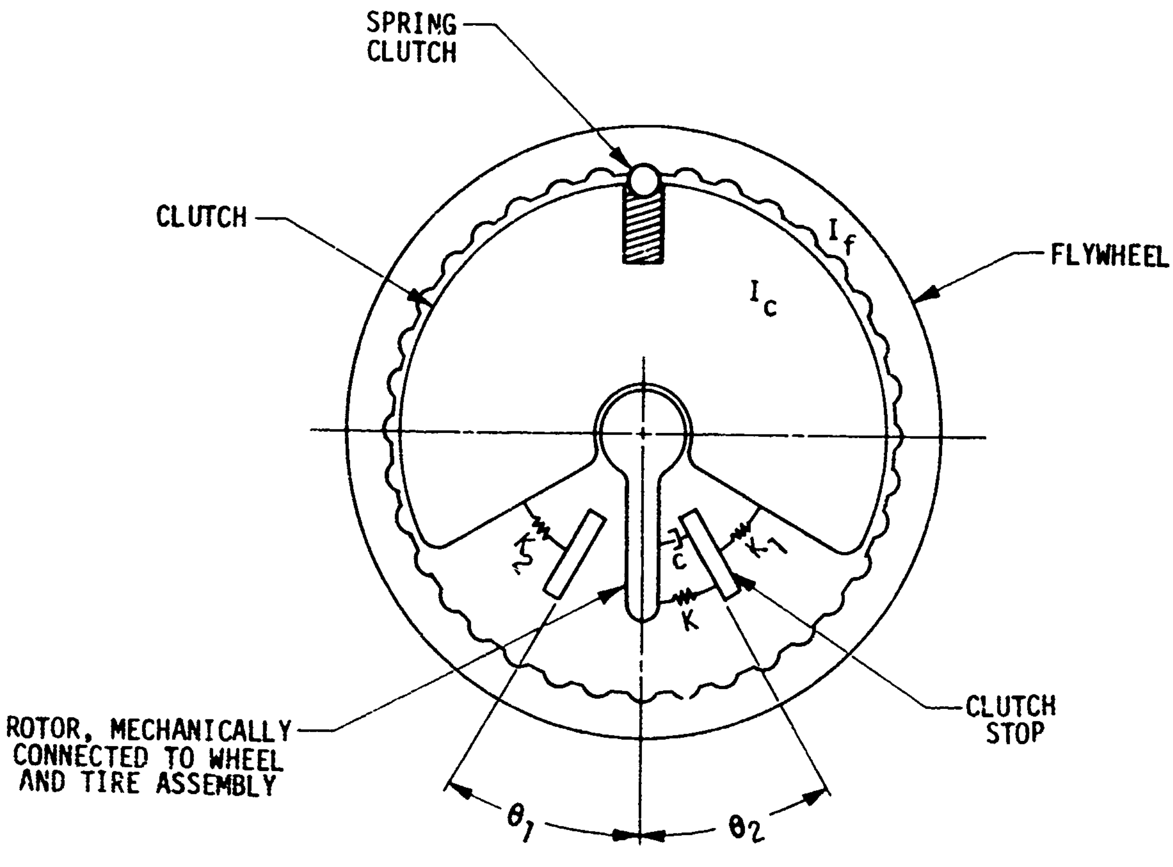

Figure 7.—B-52 Skid Detector Schematic

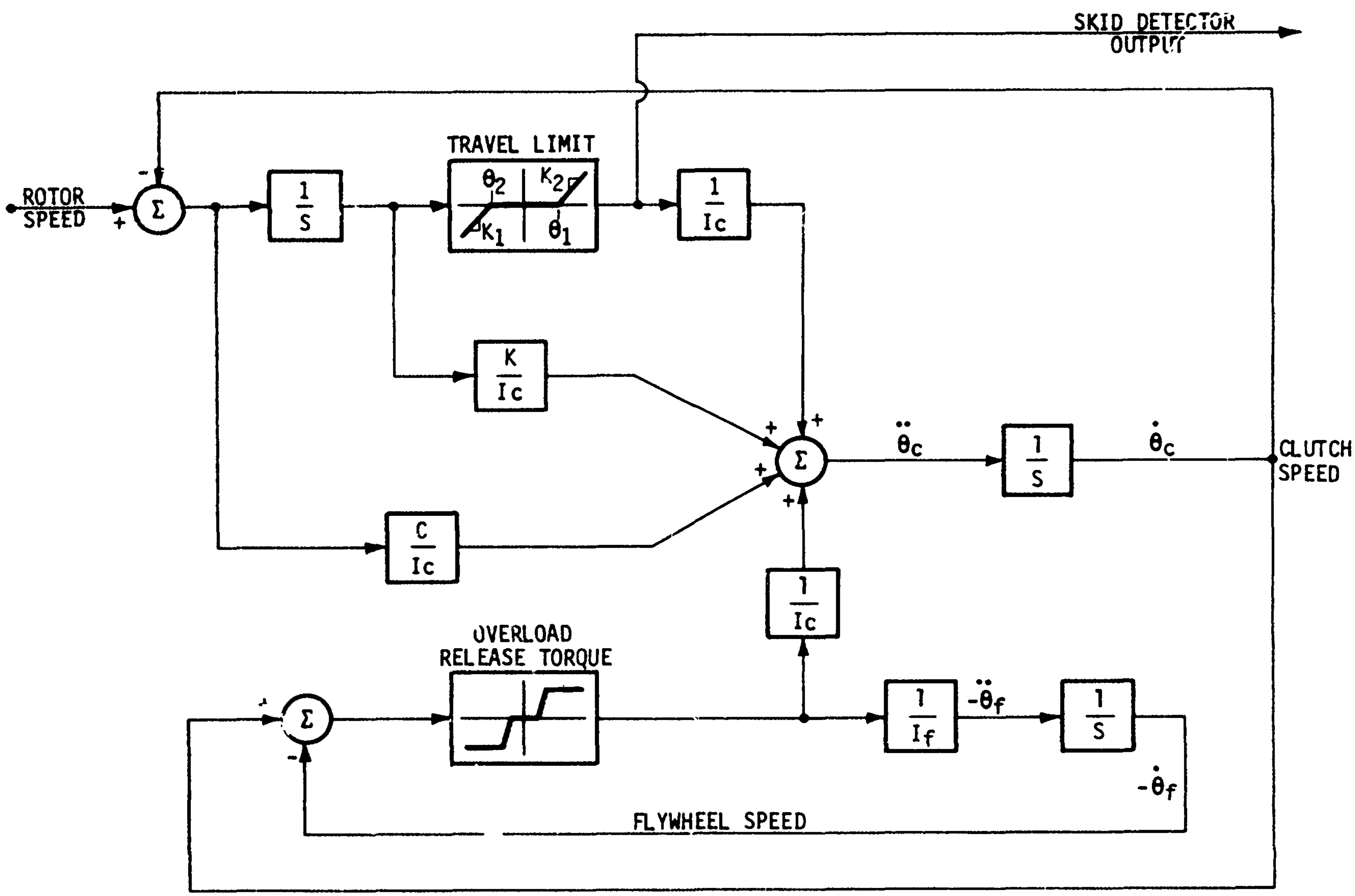

Figure 8.—B-52H Skid Detector Block Diagram

Table 4.—B-52H Skid Detector Parameters

PARAMETER	DEFINITION	UNITS	VALUE
C	Rotor-Clutch Damping Coefficient	lbf-ft-sec	6.82×10^{-4}
K	Rotor-Clutch Spring Coefficient	lbf-ft	4.15×10^{-4}
K_1, K_2	Skid Stop-Spring Coefficient	lbf-ft	6.49×10^{-2}
I_c	Clutch Inertia	lbf-ft-sec^2	1.097×10^{-6}
I_f	Flywheel Inertia	lbf-ft-sec^2	3.25×10^{-4}
T	Clutch Overload Release Torque	ft-lbf	2.156×10^{-2}
θ_1	Skid Stop Rotation Angle	Radians	.4363
θ_2	Recovery Stop Rotation Angle	Radians	.2269

To make the skid detector simulation absolutely correct, the overload release torque should be a function of position difference rather than speed difference. Due to computer limitations this aspect was compromised, however, the dynamic response of the detectors was not effected significantly.

In order to "tune" the skid detector simulation, actual hardware performance laboratory tests were conducted by connecting the detector to a high response hydraulic motor. Skid signal delay and contact times were measured as a function of initial rotor speed and deceleration rates A typical test trace is shown in Figure 9. Test results indicated the skid signal delay time is inversely related to rotor deceleration rate, as shown on Figure 10. Only a very slight dependence of delay time (less than 7%) on initial rotor velocity was noted over the test range. As shown on Figure 11, the contact time is directly dependent on initial rotor speed. Analog computer simulation results for a series of similar skid detector tests are also shown in Figure 10 and 11. Good agreement between test and simulation results can be noted.

In addition to the analog simulation of the skid detector dynamics, two electronic circuits were required to complete the detector simulation. Figure 12 depicts the circuit used to simulate the skid detector's point contact during a skid cycle. When a skid occurs, the output of the analog simulation is a high voltage which turns transistor Q1 on. Point A is grounded, completing the detector's skid circuit.

To provide locked-wheel protection, the detector's wheel speed commutator was simulated. A schematic of the resulting circuit is given in Figure 13. As shown, wheel speed from the analog computer is used to drive a voltage control oscillator (VCO) at the appropriate frequency. The output of the VCO in turn causes transistor Q2 to turn on and off simulating the commutator's action. The trim pot is used to provide adjustment of the commutator's pulse width (see Figure 13).

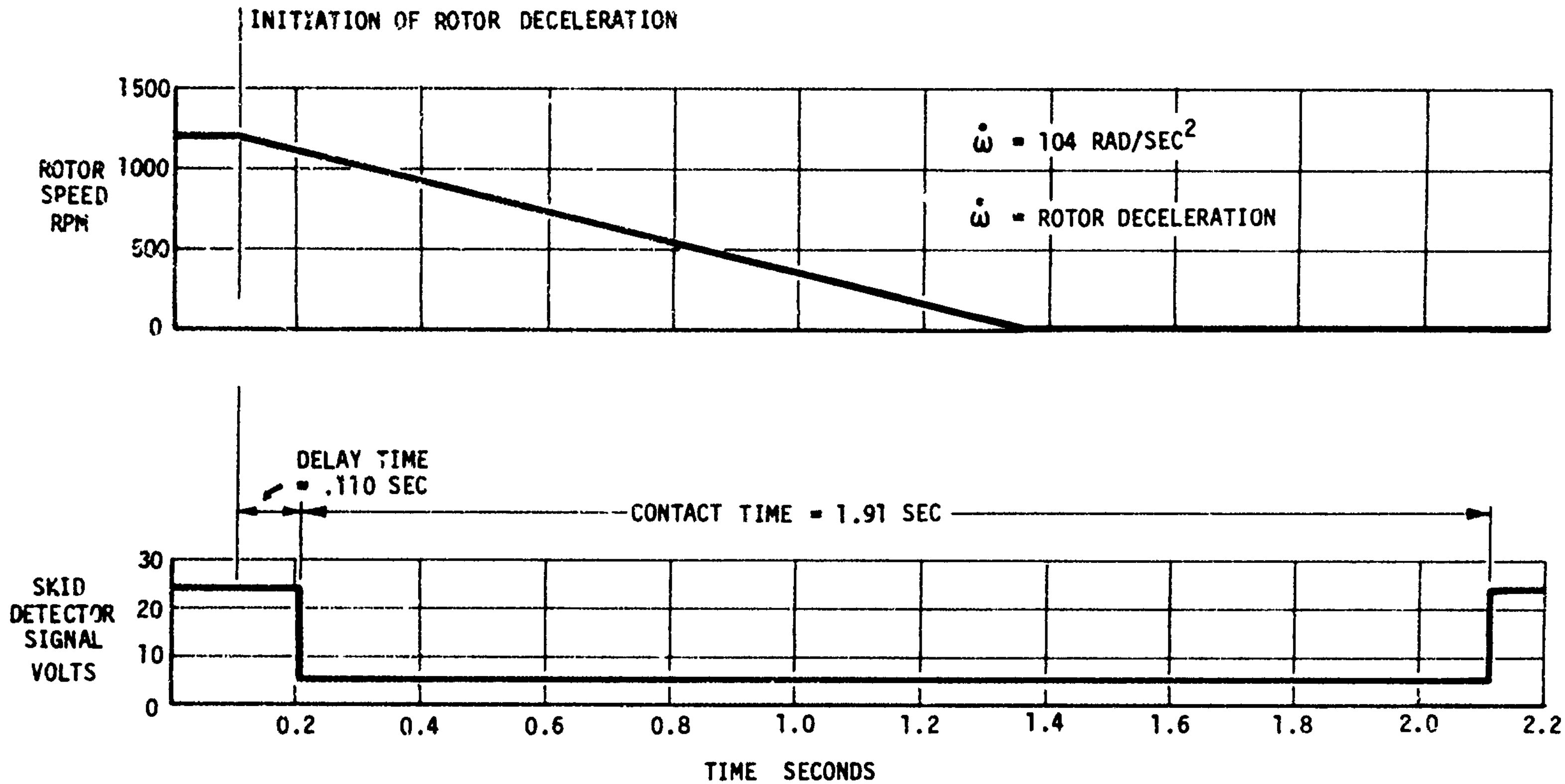

Figure 9.—B-52H Skid Detector Test Trace

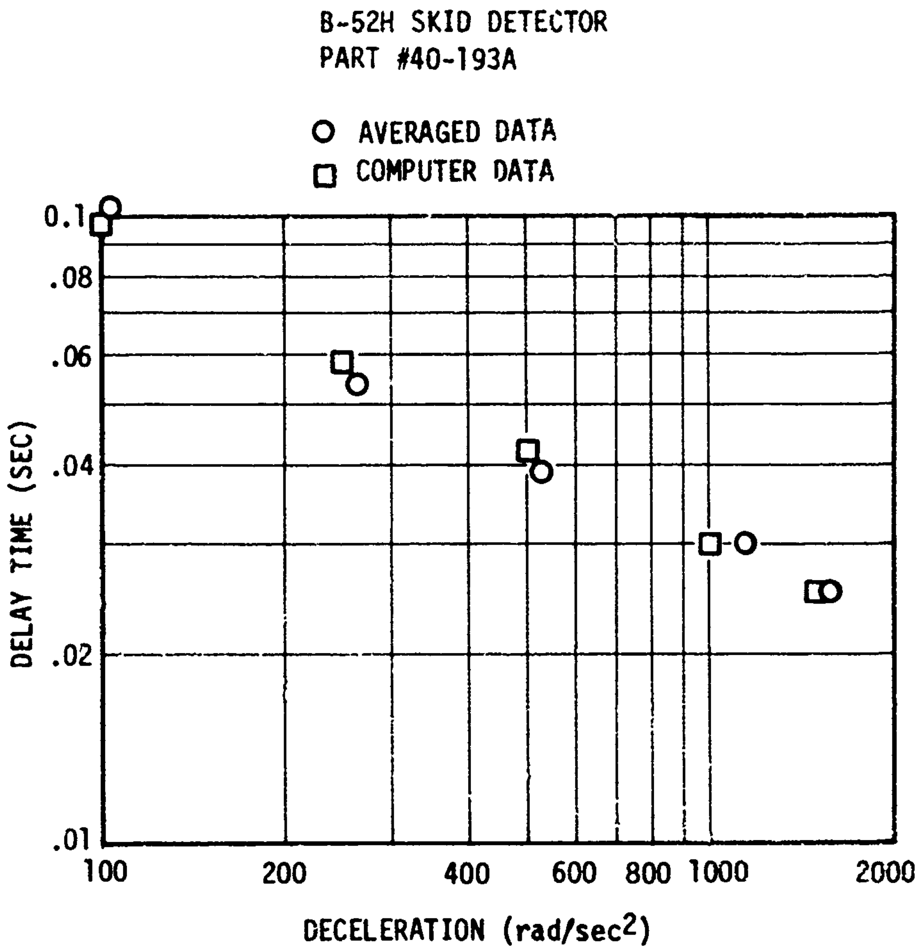

Figure 10.—B-52 Skid Detector Delay Time Vs. Deceleration

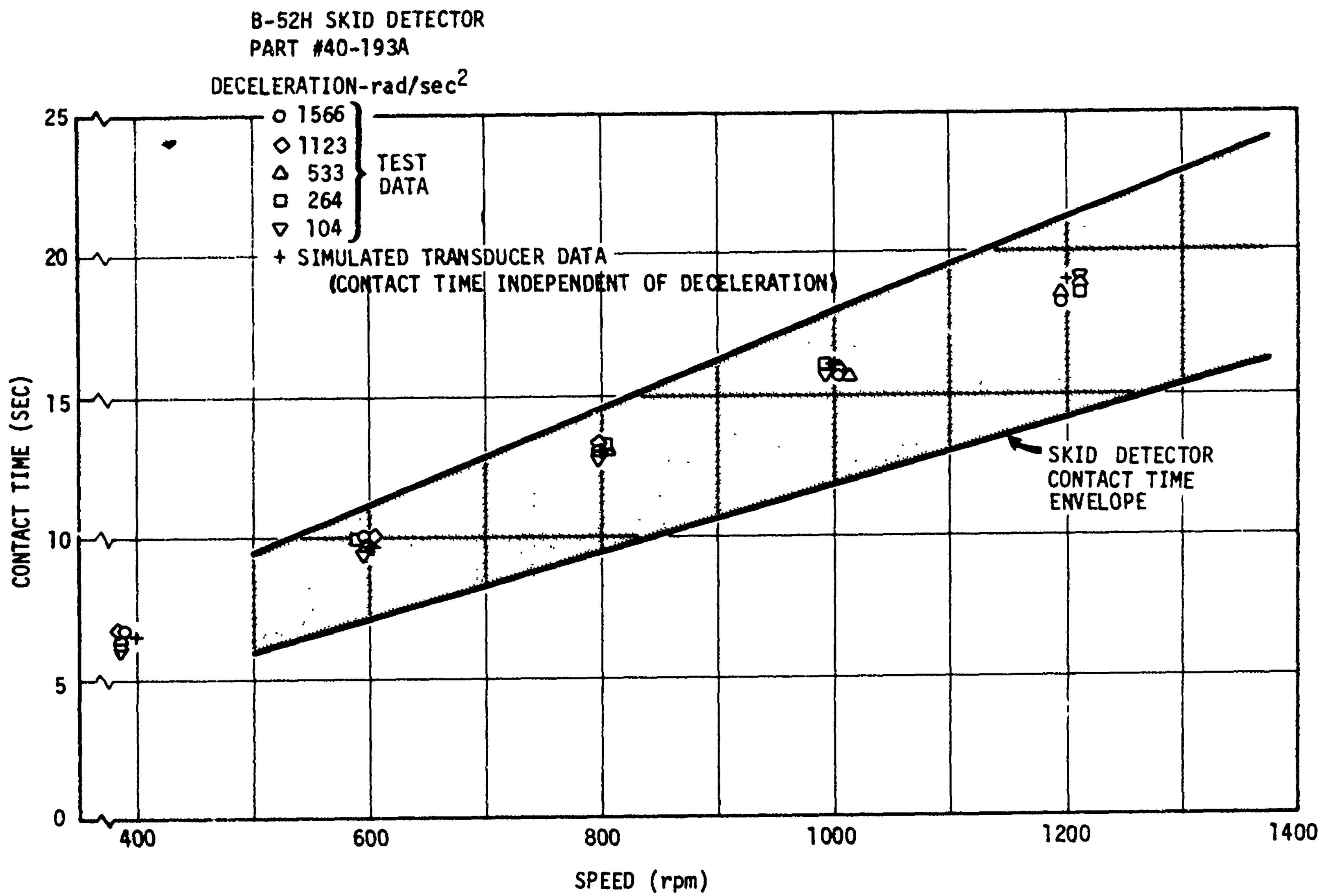

Figure 11.—B-52 Skid Detector Contact Time

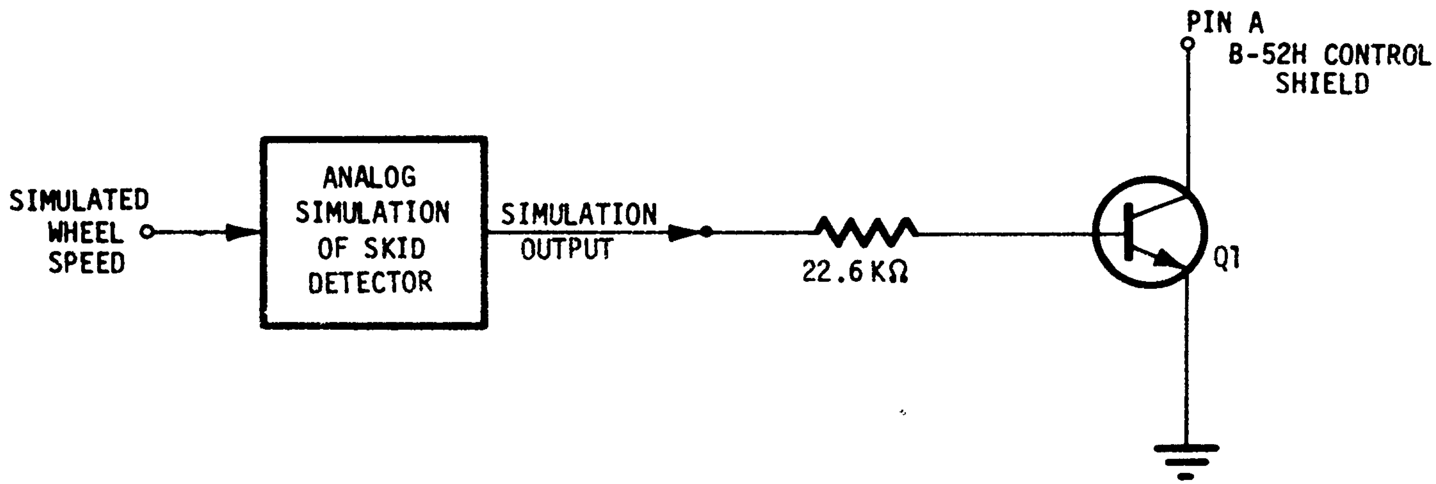

Figure 12.—B-52 Completed Skid Detector Simulation

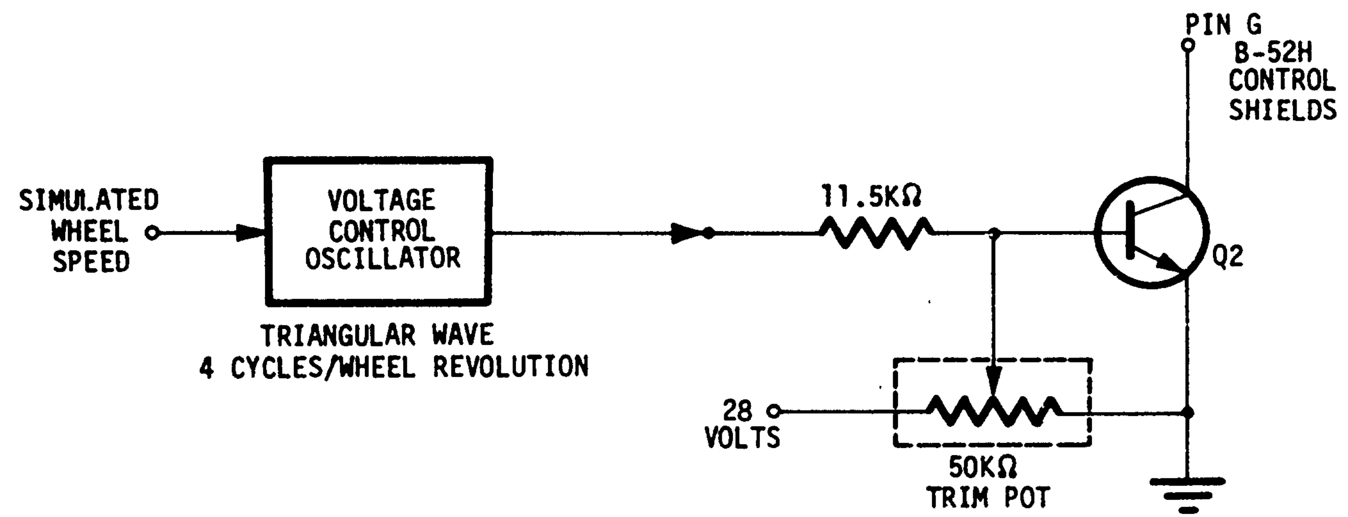

Figure 13.—B-52 Locked Wheel Protection Commutator Simulation

SECTION IV
KC-135 BRAKE CONTROL SYSTEM DESCRIPTION AND SYSTEM CHARACTERISTICS

The KC-135 sensitivity studies were conducted with the Mark II Antiskid System modification. The initial KC-135 brake system was a Mark I on-off system, while the Mark II is a modulating pressure system. Figure 14 shows the KC-135 brake hydraulic system mockup used for these tests. The mockup represents the brake hydraulics associated with one main landing gear or one-half of the brake system. Figure 15 is a schematic of the mockup and can be used to identify individual hydraulic components. In addition, this figure, along with Table 5, details the hydraulic configuration. Table 6 is included to identify the components used in the mockup.

1. SYSTEM DESCRIPTION

A. WHEEL SPEED TRANSDUCER

The KC-135 wheel speed transducer consists of a rotor and a coil assembly as shown in Figure 16. A transducer is mounted in the axle of each braked wheel with the rotor attached to the wheel by a hubcap. Rotation of the rotor produces a transducer output current with frequency proportional to wheel speed. The transducer's basic operation is as follows. Current is supplied to the coil assembly which creates a magnetic field. The rotor turns within this magnetic field. Teeth on the rotor cut through the magnetic field inducing an alternating current on the coil current. This alternating current is fed into the antiskid brake control box providing wheel speed information.

B. ANTISKID CONTROL SYSTEM

The sensitivity study of the KC-135 was conducted with a Mark II antiskid control system. The Mark II is a product of the Hydro-Aire Division of the Crane Company. A simplified block diagram of the system is presented in Figure 17.

The Mark II antiskid system requires active wheel speed information which is supplied by an A. C. wheel speed transducer located in each wheel. The A. C. signal with frequency proportional to wheel speed is received by the antiskid control box's squaring circuit. The squaring circuit converts the sinusoidal wheel speed to a square wave with frequency proportional to wheel speed. The velocity amplifier converts this signal to a D. C. voltage. The magnitude of the D. C. voltage is a measure of actual wheel speed. The D. C. wheel speed is differentiated in the deceleration amplifier to produce instantaneous wheel deceleration and compared to a fixed threshold. When the derived deceleration exceeds the threshold, a brake release signal is initiated. The duration and magnitude of the brake release is dependent upon the amount by which the threshold is exceeded. In addition to this control, a pressure bias modulation (PBM) circuit provides extended control after the wheel has recovered from a skid. The PBM is basically a capacitor circuit, during a skid the capacitor is charged to a level proportional to the duration and magnitude of the skid. After the wheel has recovered from a skid, the capacitor discharges ramping pressure on. To ensure that the same brake pressure is not reapplied after a skid, the PBM is charged to a higher level than it had prior to the skid.

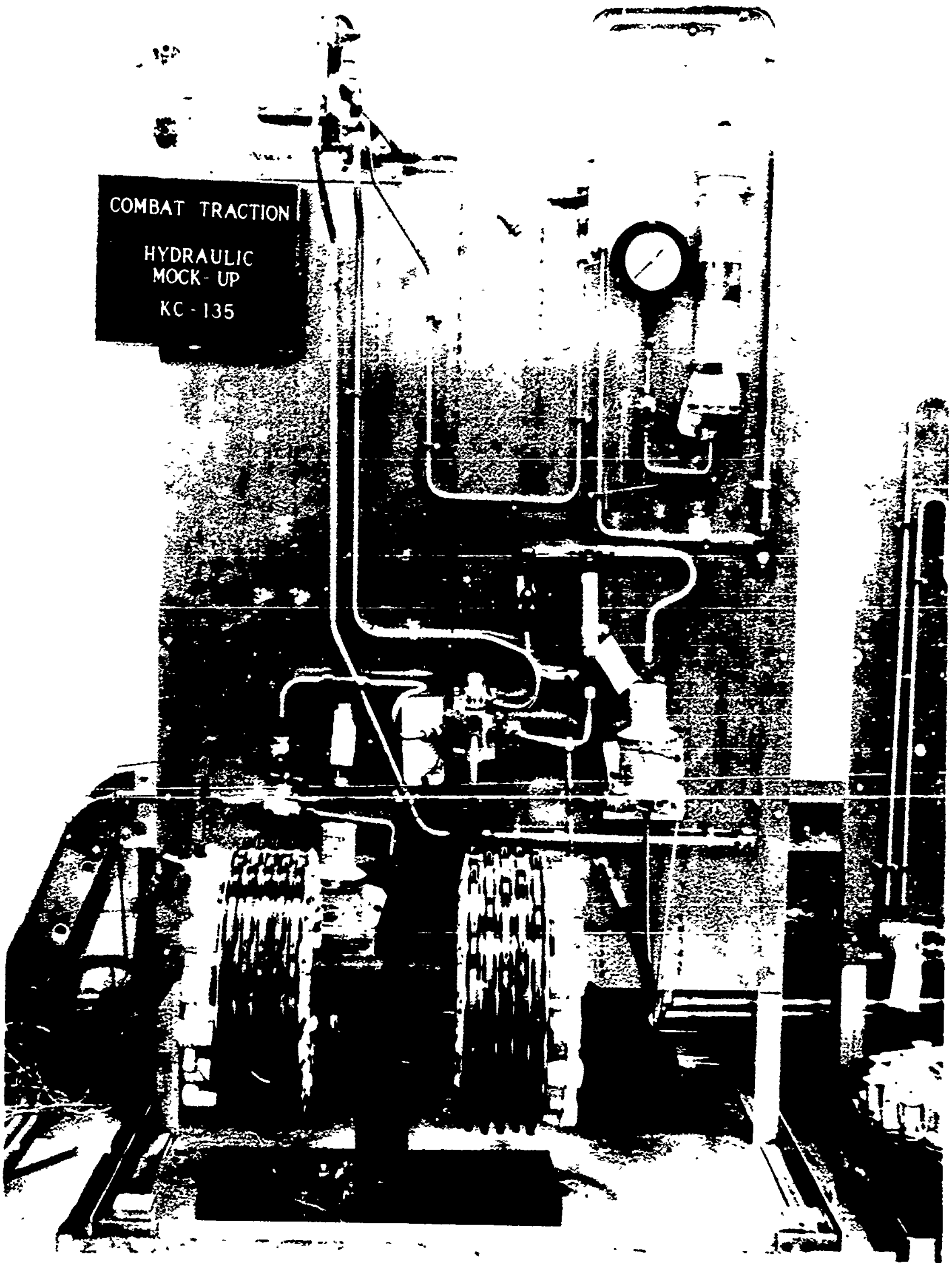

Figure 14.—KC-135 Brake Hydraulic System Mockup

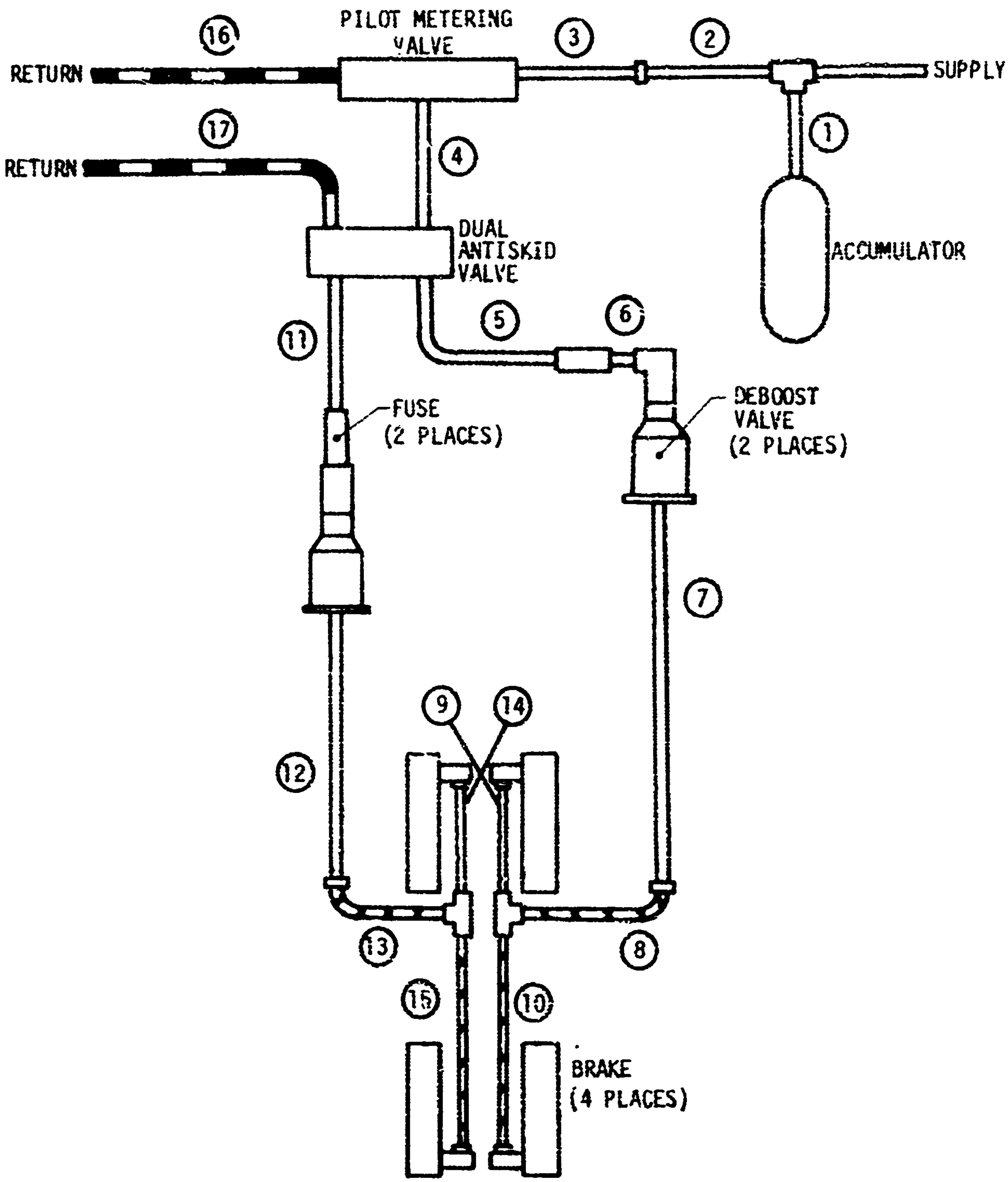

Figure 15.—KC-135 Brake Hydraulic System Schematic

Table 5.—KC-135 Brake Hydraulic System Mockup

DESCRIPTION	LINE NUMBER	LINE SIZE	LINE LENGTH (Inches)
ACCUMULATOR LINE	1	6S35	60
SUPPLY PRESSURE LINE	2	8S49	60
↓	3	6S35	60
METERED PRESSURE LINE	4	8S49	60
PORT 1 BRAKE PRESSURE LINE	5	8S49	11
	6	8S49	16
	7	8S49	170
↓	8	1/2 in.hose	81
BRAKE #1 PRESSURE LINE	9	6S35	63
BRAKE #2 PRESSURE LINE	10	3/8 in.hose	24
PORT 2 BRAKE PRESSURE LINE	11	8S49	15
	12	8S49	159
↓	13	1/2 in.hose	81
BRAKE #3 PRESSURE LINE	14	6S35	63
BRAKE #4 PRESSURE LINE	15	3/8 in.hose	24
PILOT METERING VALVE RETURN	16	8A35	AS REQUIRED
ANTISKID VALVE RETURN	17	8A35	AS REQUIRED

Table 6.—KC-135 Brake Hydraulic System Mockup Components

ITEM	NATIONAL STOCK NUMBER	QUANTITY
SKID CONTROL BOX	1630-00-918-0340	1
SKID DETECTOR	1630-00-918-0339	1
PILOT METERING VALVE	1630-00-610-7199	1
DUAL ANTISKID VALVE	1630-00-908-9999	1
FUSE	1650-00-672-8013	2
DEBOOST VALVE	1650-00-570-8397	2
ACCUMULATOR	1650-00-584-9343	1
BRAKE ASSEMBLY	1630-00-058-5242	4

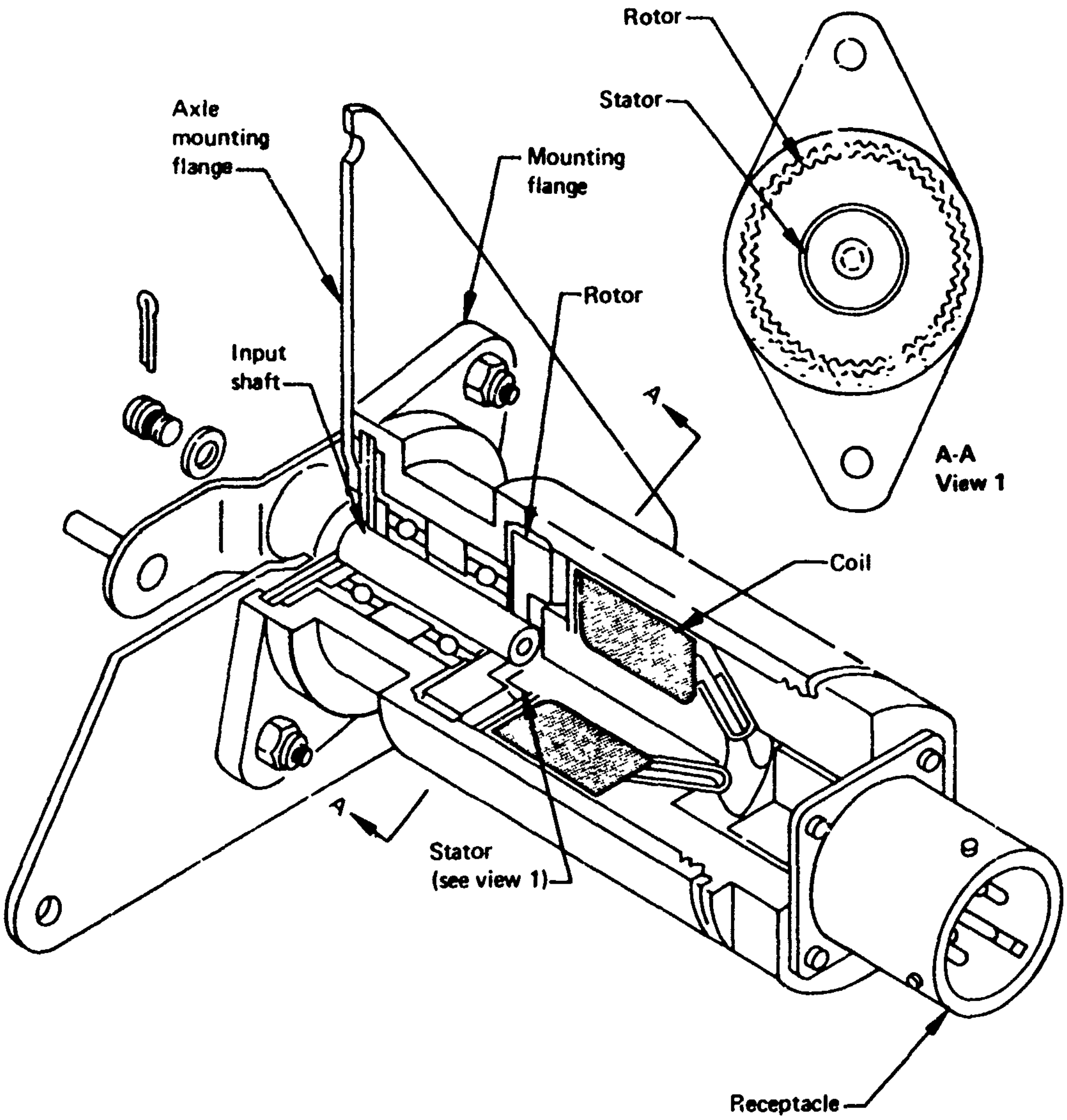

Figure 16.—KC-135 Wheel Speed Transducer

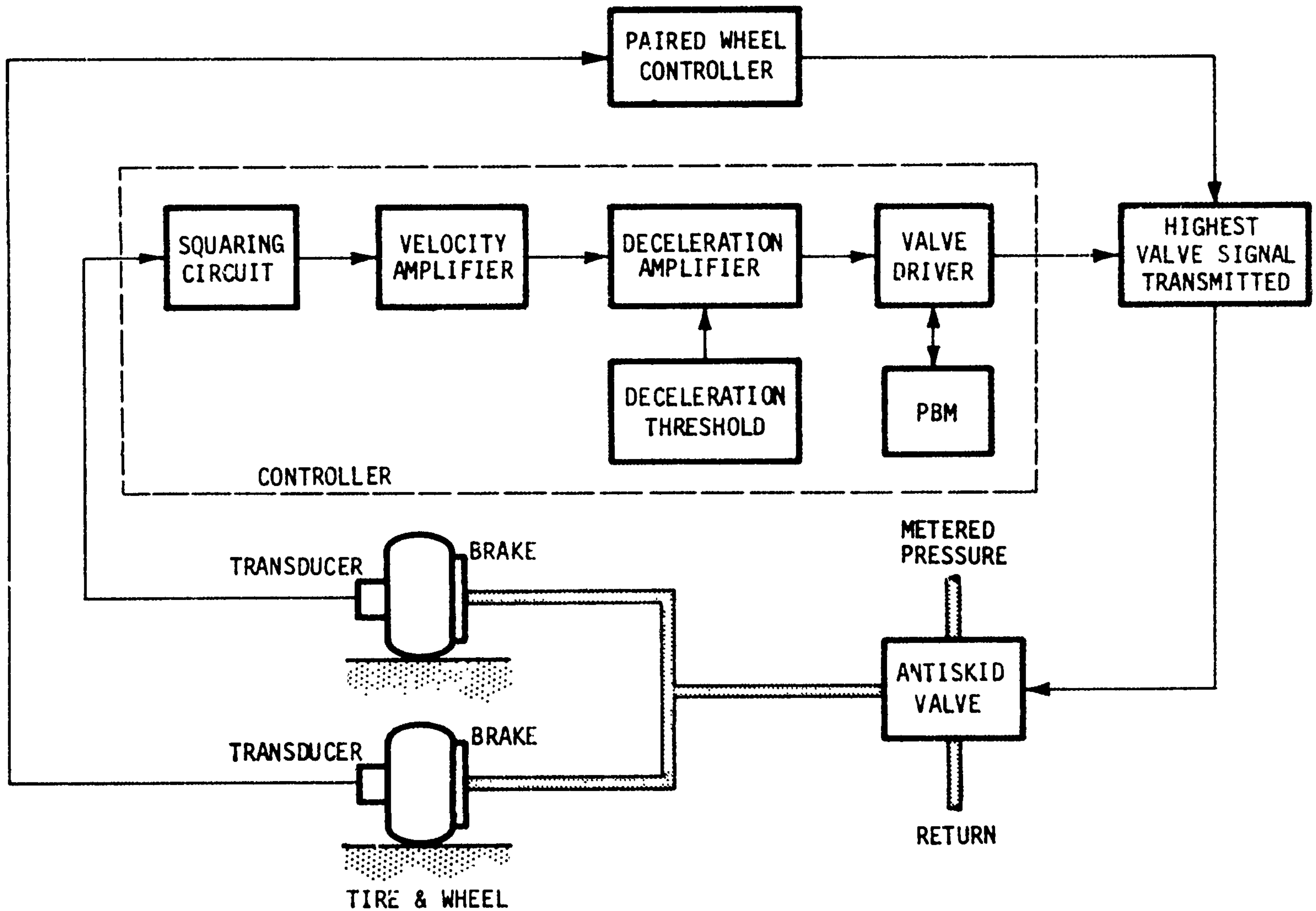

Figure 17.—KC-135 Antiskid System Block Diagram

The singals from the PBM and deceleration amplifier provide the input to the valve dirver. The valve driver provides current to the antiskid valve in relationship to input voltage.

C. TOUCHDOWN AND LOCKED-WHEEL PROTECTION

Locked-wheel protection in the Mark II antiskid system consists of an arming circuit and a detection circuit. The four inboard wheels are combined to form one locked-wheel set, the remaining four outboard wheels form another locked-wheel set. The system is armed when either of the locked-wheel sets are rotating faster than 20 knots. If a wheel speed drops below 15 knots after the system is armed, a signal is then produced to completely remove brake pressure. Locked-wheel protection exists as long as at least one wheel in the set is rotating above 20 knots. If all four wheels in a set lock simultaneously no locked-wheel protection exists.

Squat switch logic arms the system in the air to provide touchdown protection.

D. BRAKE HYDRAULIC SYSTEM

The KC-135 brake hydraulic system as pictures in Figure 14 and 15 consists of the following major components: an accumulator, a pilot metering valve, an antiskid valve, two deboost valves, and four brakes. During normal operation the pilot metering valve is supplied 3000 psi hydraulic pressure from the utility pressure system. The accumulator in the supply line serves two functions. Under normal conditions the accumulator decreases fluctuations in supply pressure due to large flow demands; in case of hydraulic power loss or shutdown the accumulator supplies limited hydraulic pressure to the brake system.

The pilot metering valve is a pressure control valve with output pressure proportional to the force applied to the valve's actuator levers. The pilot controls the force through a mechanical brake pedal and cable linkage. The function of the pilot metering valve in the brake system is to control the maximum pressure available to the antiskid valve. Output pressure from the metering valve enters a dual antiskid valve. From each of the two antiskid valve output ports, pressure is routed through a deboost valve to two brakes.

The dual antiskid valve is an electro-hydraulic pressure control valve. It has two individual hydraulic circuits, each of which is controlled by a separate current input. Figure 18 is a schematic of the valve, however, only one hydraulic circuit is shown The valve contains two stages. The first stage is designed to convert the electrical signal from the skid control box into a hydraulic signal. A torque motor, nozzles and flapper make up the first stage. The application of current to the torque motor causes the flapper to move from the neutral position (maximum pressure). Movement creates a pressure imbalance in the hydraulic bridge formed by the nozzles. This differential pressure is applied to the second stage spool. The resulting hydraulic force imbalance causes the spool to move allowing brake pressure to change. As the ouput (brake) pressure changes, hydraulic feedback causes the forces on the spool to approach equilibrium. When a force balance occurs, both the spool position and brake pressure are in equilibrium. Thus, modulation of the electrical signal results in a modulation of brake pressure.

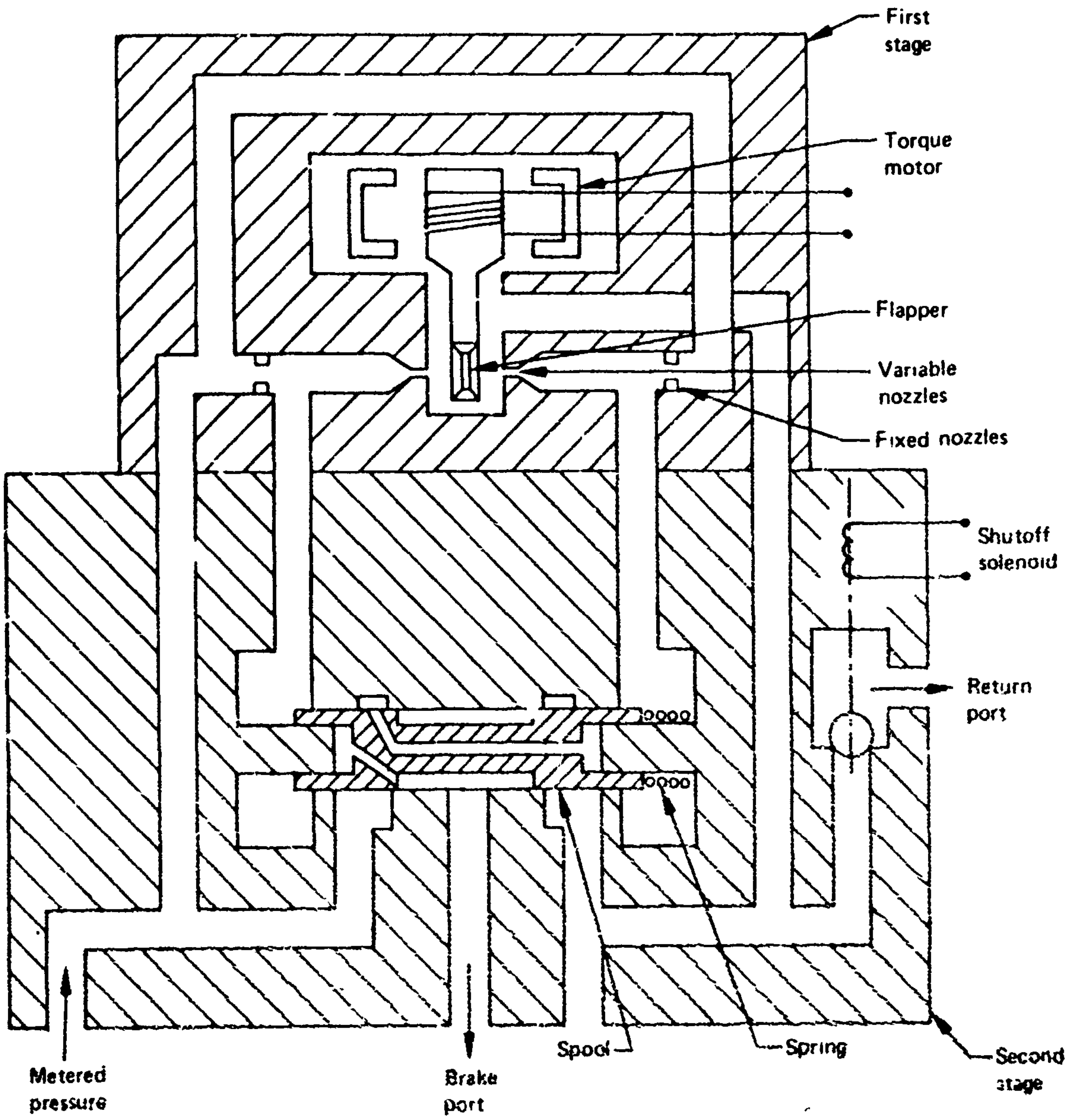

Figure 18.—KC-135 Antiskid Valve Schematic (Shown Deenergized)

The deboost valve between the antiskid valve and brake simply reduces the line pressure. The pressure ratio (output antiskid valve pressure to brake pressure) for the KC-135 is 3.11 to 1.

As noted previously a single antiskid valve output supplies pressure to two brakes. The KC-135 has a four wheel truck type gear. A forward and aft brake on each side of the truck are paired to receive a common antiskid pressure.

E. BRAKES

The Mark II antiskid system modification of the KC-135 incorporates a 5 rotor disk type brake Modulation of brake pressures causes compression or relaxation of the brake stack resulting in controlled braking action.

2. BRAKING SYSTEM CHARACTERISTICS

Various characteristics of the KC-135's brake hydraulic system were measured during the sensitivity study. The dynamic response of the hydraulic system is pictured in Figures 19 and 20. Figure 19 is a respresentative plot of frequency response, while Figure 20 is a typical step response. Tables 7 and 8 are a compilation of the dynamic response data resulting from the sensitivity study.

The Mark II antiskid valve used on the KC-135 is a pressure control valve. Figure 21 is a plot of the valve's pressure-current characteristic. The effect of varying the metered pressure is depicted by the three different curves. The pressure-volume characteristic of the five rotor KC-135 brake is shown in Figure 22.

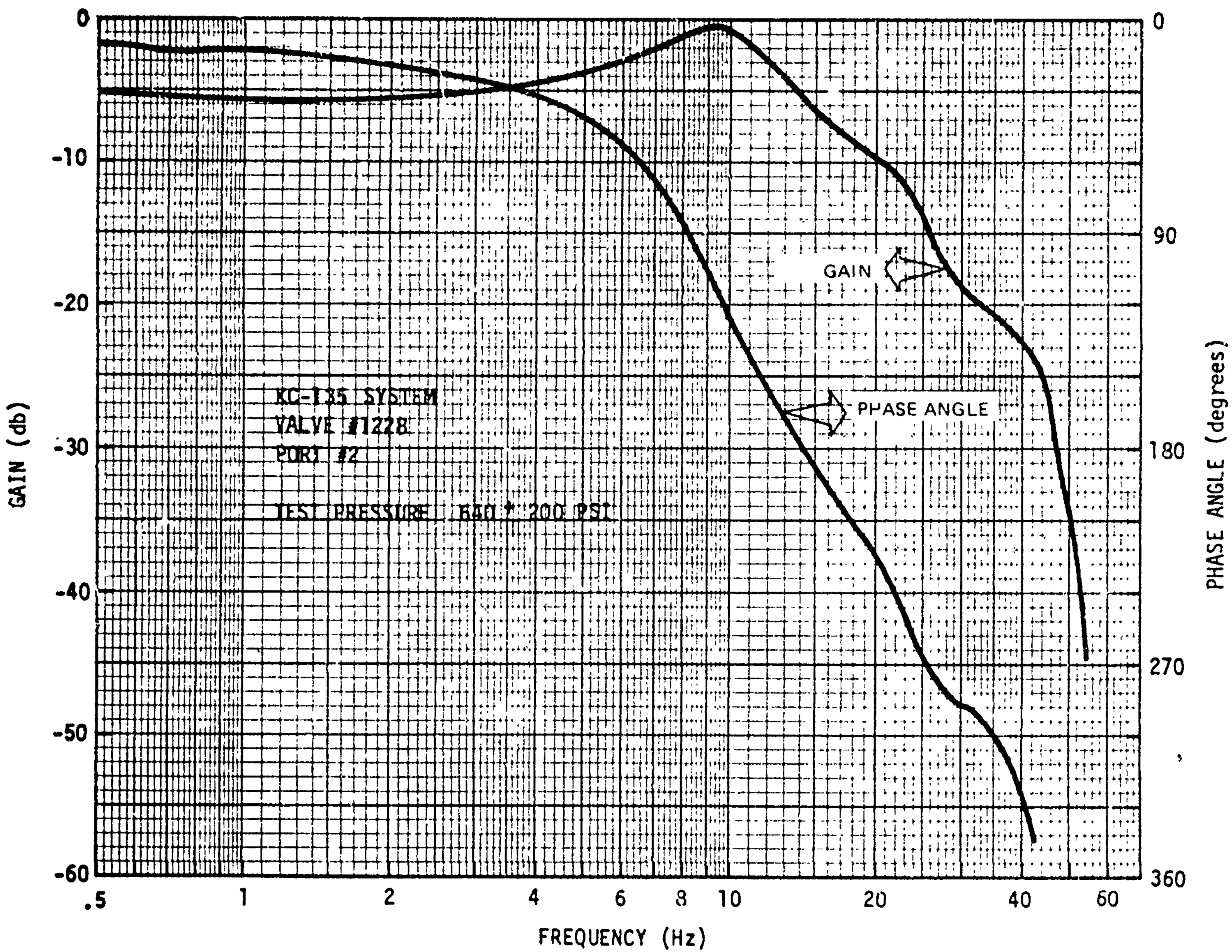

Figure 19.—KC-135 Brake Hydraulic System Frequency Response

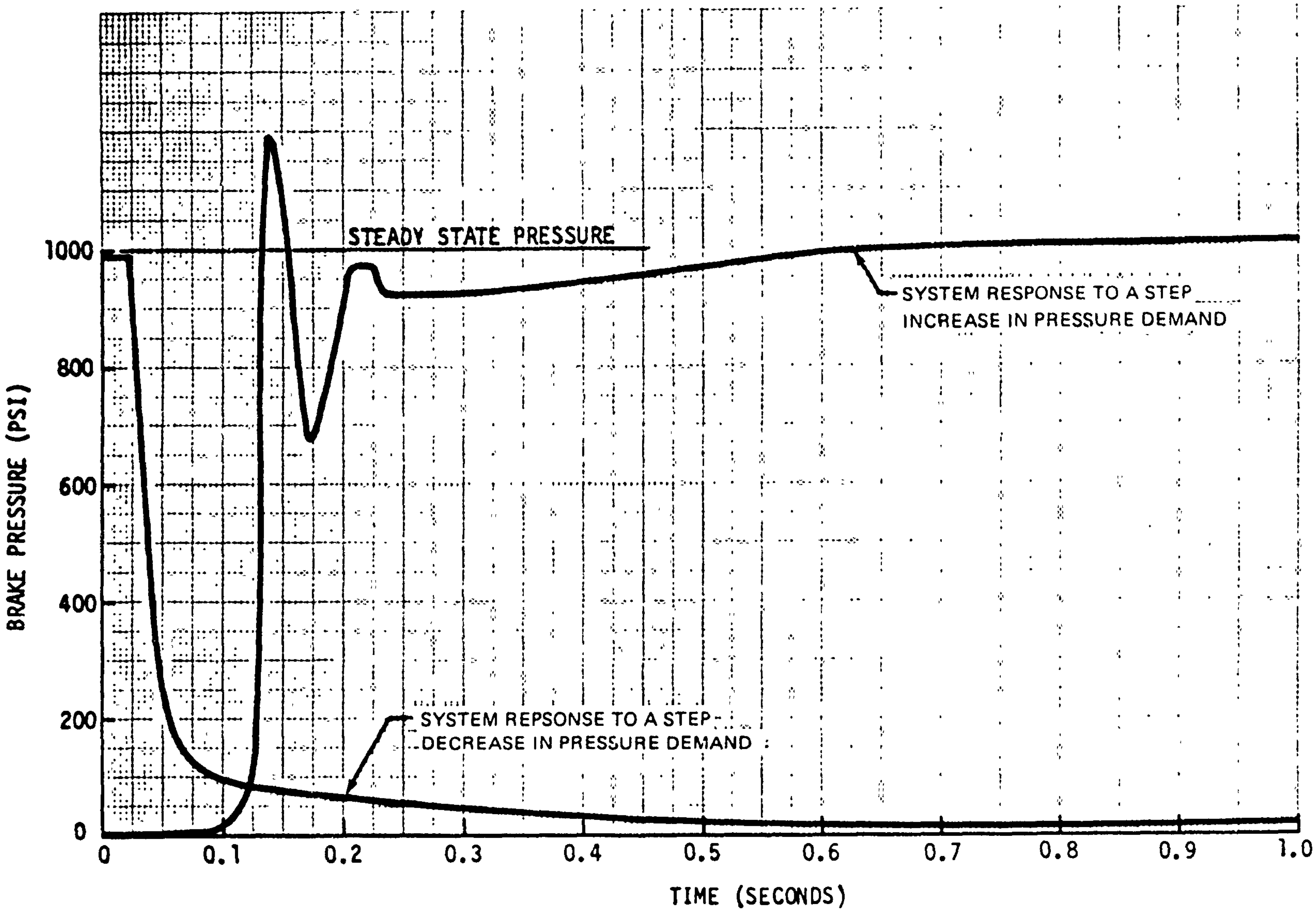

Figure 20.—KC-135 Brake Hydraulic Step Response

Table 7.—KC-135 Frequency Response Data

TEST CONDITION	TEST PRESSURE (psi)	RESONANCE POINT FREQUENCY OR -3db FREQUENCY (H_z)	GAIN AT RESONANCE OR -3db (db)	PHASE ANGLE AT RESONANCE OR -3db (degrees)	FREQUENCY AT 90° PHASE ANGLE (H_z)
STANDARD HYDRAULIC CONFIGURATION					
PORT #1	640 ± 200	9	4	96	8.6
	340 ± 200	8.8	-3	158	5.6
PORT #2	640 ± 200	9.2	5	110	8.3
	340 ± 200	5.5	2	86	5.7

VALVE SERIAL NUMBER 1228

Table 8.—KC-135 Step Response Data

TEST CONDITION	PRESSURE STEP CHANGE (psi)	DELAY RESPONSE TIME (SEC)		RESPONSE TIME TO 80% OF PRESS. CHANGE (SEC)		PERCENTAGE PRESSURE OVERSHOOT OF STEP CHANGE	
		PRESSURE INCREASE	PRESSURE DECREASE	PRESSURE INCREASE	PRESSURE DECREASE	PRESSURE INCREASE	PRESSURE DECREASE
STANDARD HYDRAULIC CONFIGURATION	0 - 965	.122	.025	.132	.057	22.3	0
	0 - 870	.135	.012	.147	.052	19.5	0
(RIGHT BRAKES)	0 - 460	.175	.020	.237	.215	4.3	0
	120 - 965	.027	.025	.042	.050	63.3	4.7
	120 - 870	.025	.015	.042	.042	65.3	5.3
STANDARD HYDRAULIC CONFIGURATION	0 - 965	.127	.025	.142	.057	24.4	0
	0 - 870	.140	.015	.157	.050	19.5	0
(LEFT BRAKES)	0 - 460	.155	.015	.200	.182	8.6	0
	120 - 965	.025	.015	.042	.037	63.3	4.7
	120 - 870	.032	.015	.048	.037	65.3	5.3

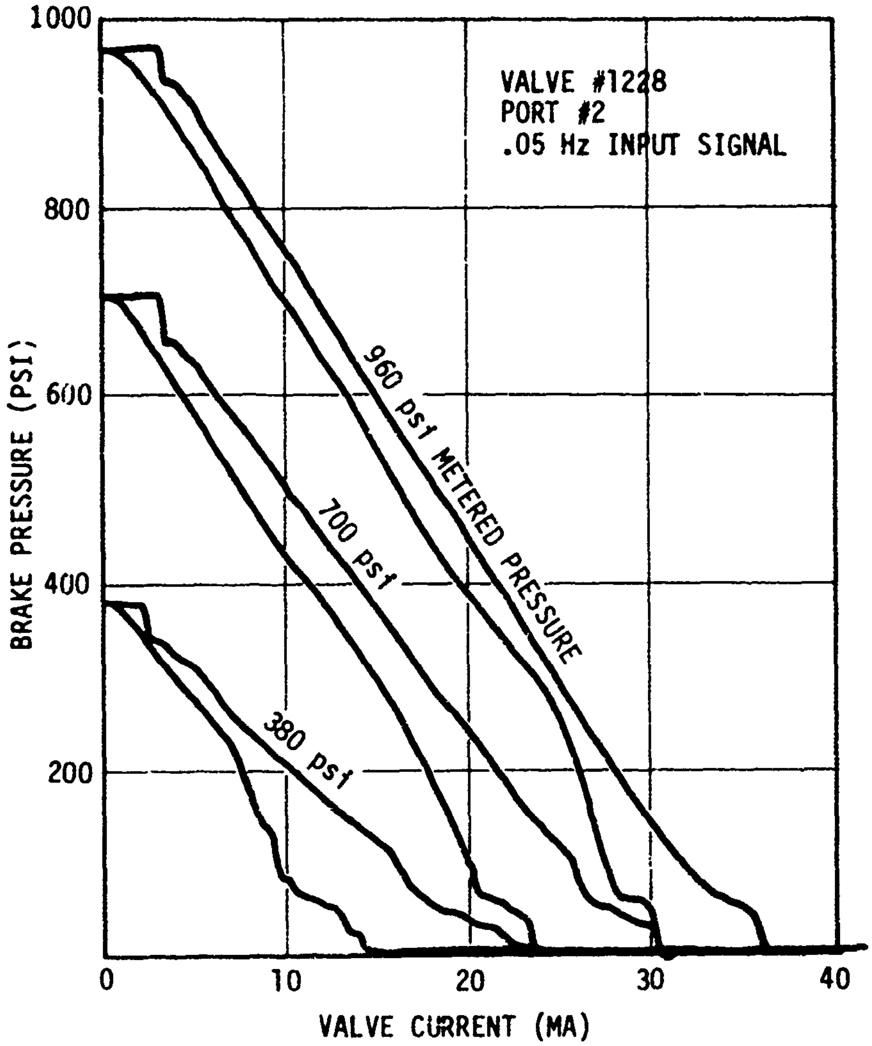

Figure 21.—KC-135 Antiskid Valve Pressure-Current Characteristics

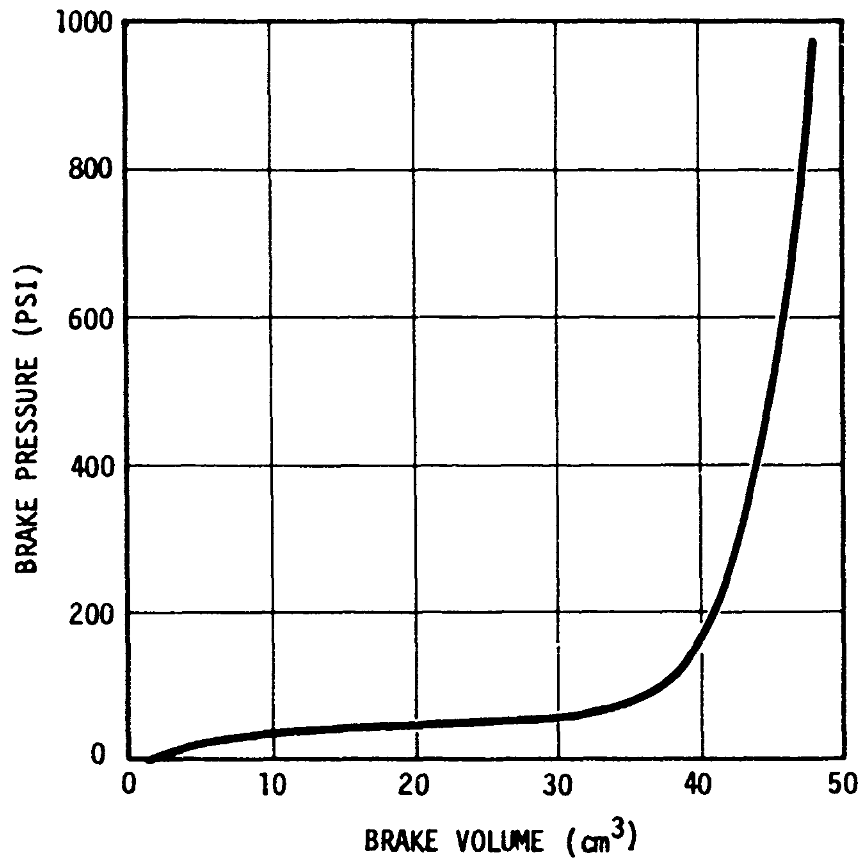

Figure 22.—KC-135 Brake Pressure-Volume Characteristic

SECTION V
F-111 BRAKE CONTROL SYSTEM DESCRIPTION AND SYSTEM CHARACTERISTICS

The sensitivity study of the F-111 made use of the brake hydraulic system mockup pictured in Figure 23. The mockup, using actual hardware, duplicates the entire brake hydraulic system of the aircraft. The hydraulic system schematic, Figure 24, identifies the pertinent system components. This figure along with Table 9, defines the significant dimensions and tubing materials used in the mockup. Table 10 is included to detail the actual aircraft hardware used in the mockup and simulator.

1. SYSTEM DESCRIPTION

A. WHEEL SPEED TRANSDUCER

The F-111 wheel speed transducer provides instantaneous wheel speed information to the skid control box. The transducer, as pictured in Figure 25, is a D. C voltage generator producing a signal proportional to wheel speed. The device is completely self-contained and is mounted in the axle. The armature of the generator is attached to the wheel and rotates with it. The basic parts of the transducer as shown in Figure 25 are a permanent magnet, armature, commutator, and brush assembly. Rotation of the commutator in the magnet field induces an electrical signal proportional to wheel speed.

B. ANTISKID CONTROL SYSTEM

The brake control system employed on the F-111 is manufactured by the Goodyear Tire and Rubber Company. The basic control elements of the system are represented in the block diagram of Figure 26. The wheel speed transducers mounted in each wheel provide instantaneous wheel speed information to the control box. During normal antiskid operation the transducer provides wheel deceleration information. This is accomplished within the deceleration detector, where the wheel speed is differentiated to produce deceleration. This deceleration is then compared with a threshold. When the deceleration threshold is exceeded a signal is applied to the valve driver. The signal from the driver is proportional to the output of the comparator, plus any signal from the pressure bias circuit. The valve driver output is applied to the antiskid valve, and a modulator circuit. The modulator, coupled with the pressure bias circuit, provides an extension of the original control signal after the wheel has recovered from a skid. The modulator charges to a level proportional to the frequency, magnitude and duration of skid signals. After recovery of the wheel from a skid, the modulator discharges. When applied to the valve driver through the pressure bias circuit, the modulator signal ensures that a lower brake pressure is applied after a skid. In addition, as the modulator discharges, brake pressure is ramped on. The modulator signal is also applied to the deceleration threshold, automatically adjusting it to meet the existing braking condition.

C. TOUCHDOWN AND LOCKED WHEEL PROTECTION

Touchdown protection is provided on the F-111 to prevent application of brake pressure prior to main gear touchdown. A squat switch is used to provide a logic signal to the antiskid circuit.

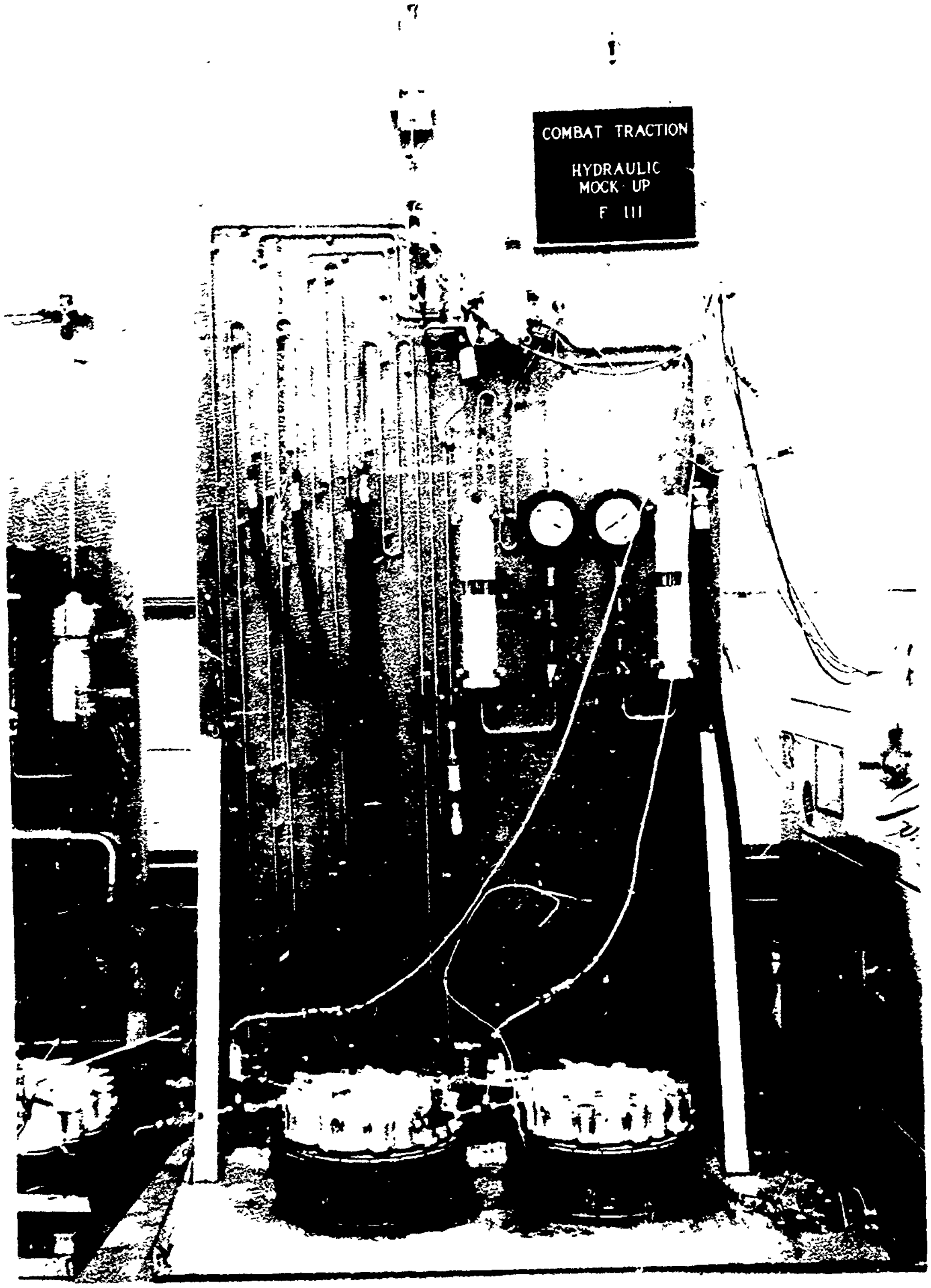

Figure 23.—F-111A Brake Hydraulic System Mockup

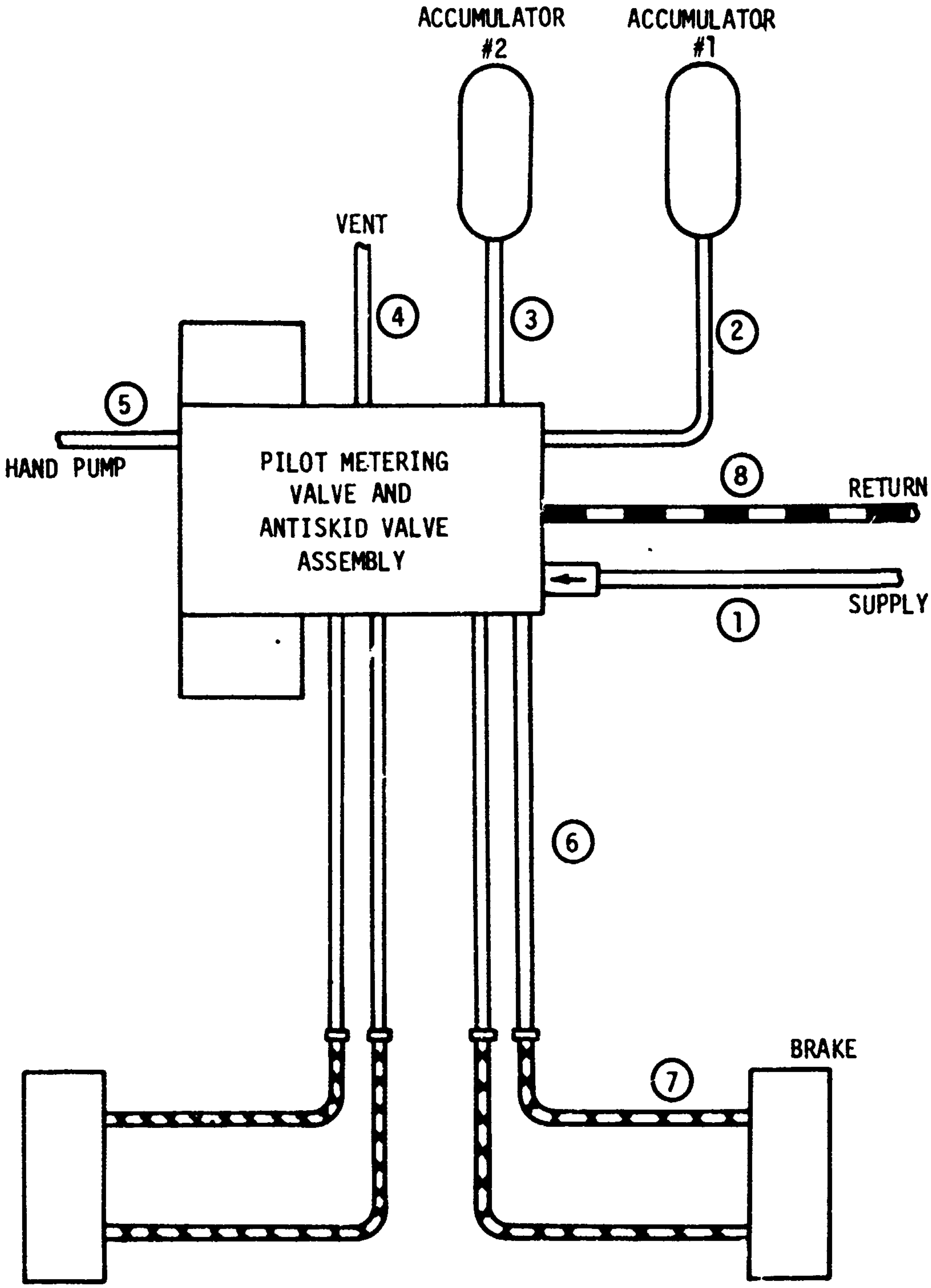

Figure 24.—F-111 Brake Hydraulic System Schematic

Table 9.—F-111 Brake Hydraulic System Mockup

DESCRIPTION	LINE NUMBER	LINE SIZE	LINE LENGTH (IN)
SUPPLY PRESSURE LINE	1	4S20	30
ACCUMULATOR #1 LINE	2	4S20	50
ACCUMULATOR #2 LINE	3	4S20	30
VENT LINE	4	8S28	35 Not on mock-up
HAND PUMP PRESSURE	5	4S20	78 Not on mock-up
BRAKE PRESSURE LINE	6	4S20	192 Typical 4 places
	7	1/4" hose	60 Typical 4 places
RETURN PRESSURE LINE	8	8A28	50

Table 10.—F-111 Brake Hydraulic System Mockup Components

ITEM	PART NUMBER	QUANTITY
SKID CONTROL BOX	1630-00-050-7726	1
SKID DETECTOR	6115-00-939-3245 LE	1
VALVE ASSEMBLY		
PILOT METERING VALVE	1630-00-925-3156	1
ANTISKID VALVE	1630-00-949-7849	2
ACCUMULATOR	1650-00-880-3176	2
BRAKE ASSEMBLY	1630-00-082-7955	2

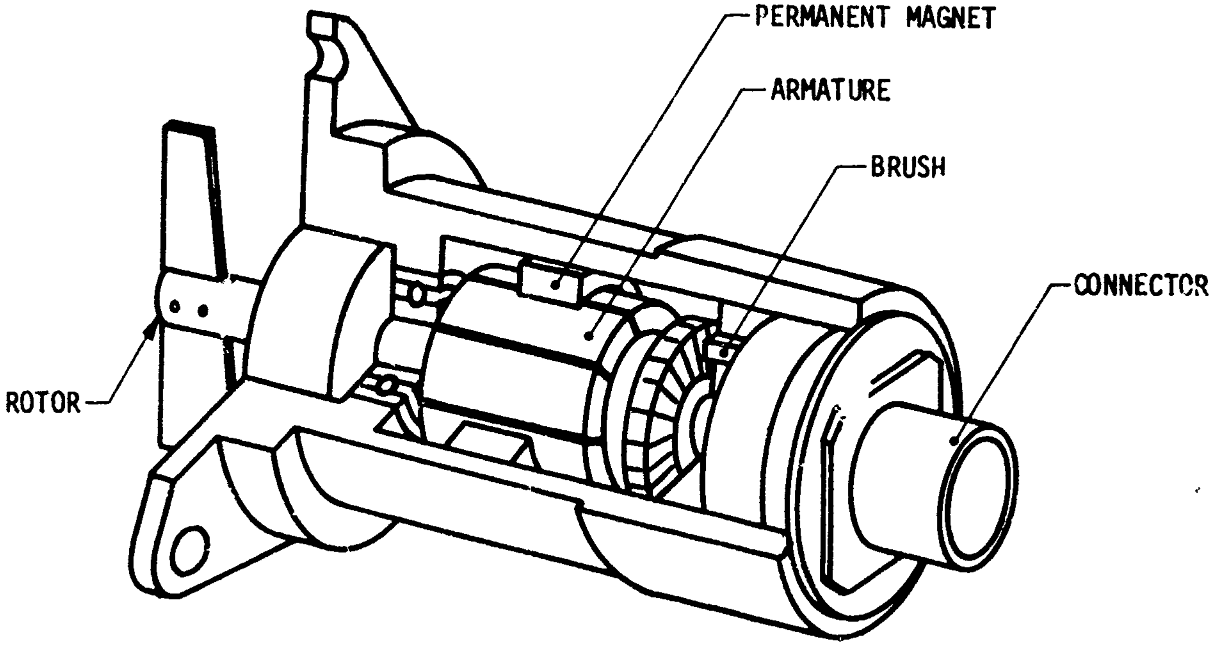

Figure 25.—F-111 Wheel Speed Transducer

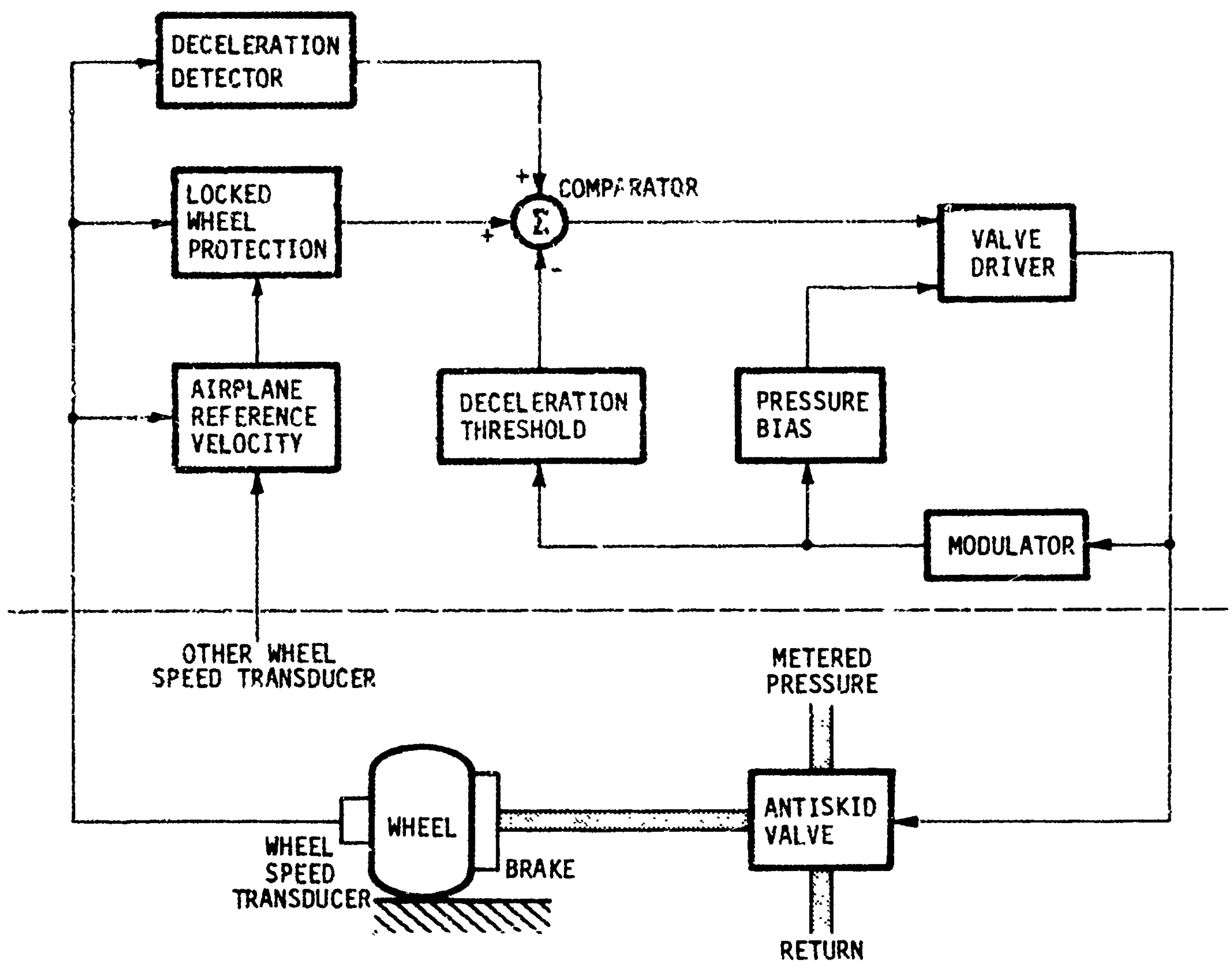

Figure 26.—F-111 Antiskid System Block Diagram

Prior to airplane touchdown the circuit supplies a dump command to the antiskid valve which prevents metered pressure from entering the brakes. A wheel speed signal above 20 knots will over-ride touchdown protection.

Locked wheel protection is provided by comparing the wheel speed signals from the F-111's main gear wheels. In the event one wheel speed drops below 20 knots, the locked wheel protection logic supplies a brake release signal to the antiskid valve of the low speed wheel. If the wheel does not spin up after 1.35 seconds (approximate) the antiskid system is automatically de-energized.

D. BRAKE HYDRAULIC SYSTEM

The F-111 brake hydraulic system is composed of two accumulators, a pilot metering valve, two antiskid valves, hydraulic tubing and brakes. Hydraulic pressure at 3000 psi is supplied to the metering valve by the utility hydraulic system during normal operation. In emergency and power off braking situations the two hydraulic accumulators provide pressure for braking.

The brake hydraulic system is a dual-normal design, two independent hydraulic circuits supply pressure to each brake. This design, along with a directional control requirement, results in a need for four pilot metering valves. Each metering valve controls pressure to one hydraulic circuit. The metering valve is a pressure control valve, its output is directly proportional to the force applied to the valve's actuator lever. The force is controlled by the pilot from the cockpit through conventional brake pedals mechanically linked to the metering valve actuator. Pressure from the meter valve enters an antiskid valve and is then routed to the brake.

The antiskid valve is an electrically operated pressure control valve and is shown schematically in Figure 27. The purpose of the valve is to modulate the brake pressure eliminating deep wheel skids. The antiskid valve receives its electrical control signal from the skid control box. As seen in Figure 27, the valve's basic components are a linear force motor, a first stage spool and sleeve and two second stage spools and sleeves. The valve's basic operation is as follows. An electrical signal is applied to the linear force motor, generating an imbalance of forces on the first stage spool. First stage control pressure will change until the pressure force equals the motor force. The resulting control pressure is applied to the second stage, causing a force imbalance on the spool. The second stage output pressure will change until it balances the force due to the first stage control pressure. Second stage pressure is directed to the brakes. Modulation of the electrical signal to the first stage ultimately results in brake pressure modulation.

The pilot metering valve and antiskid valves on the F-111 have been integrated into one assembly. The essential hydraulic circuits of the unit are shown in Figure 27.

E. BRAKES

The F-111A has two main wheel brakes per aircraft. The brakes are a multiple disk-type assembly, each consisting of rotors, stators, pressure plate, hydraulic housing and pressure pistons. The housing contains two independent pressure chambers, with each chamber actuating one-half the pressure pistons. When brake pressure is applied, the pressure pistons force

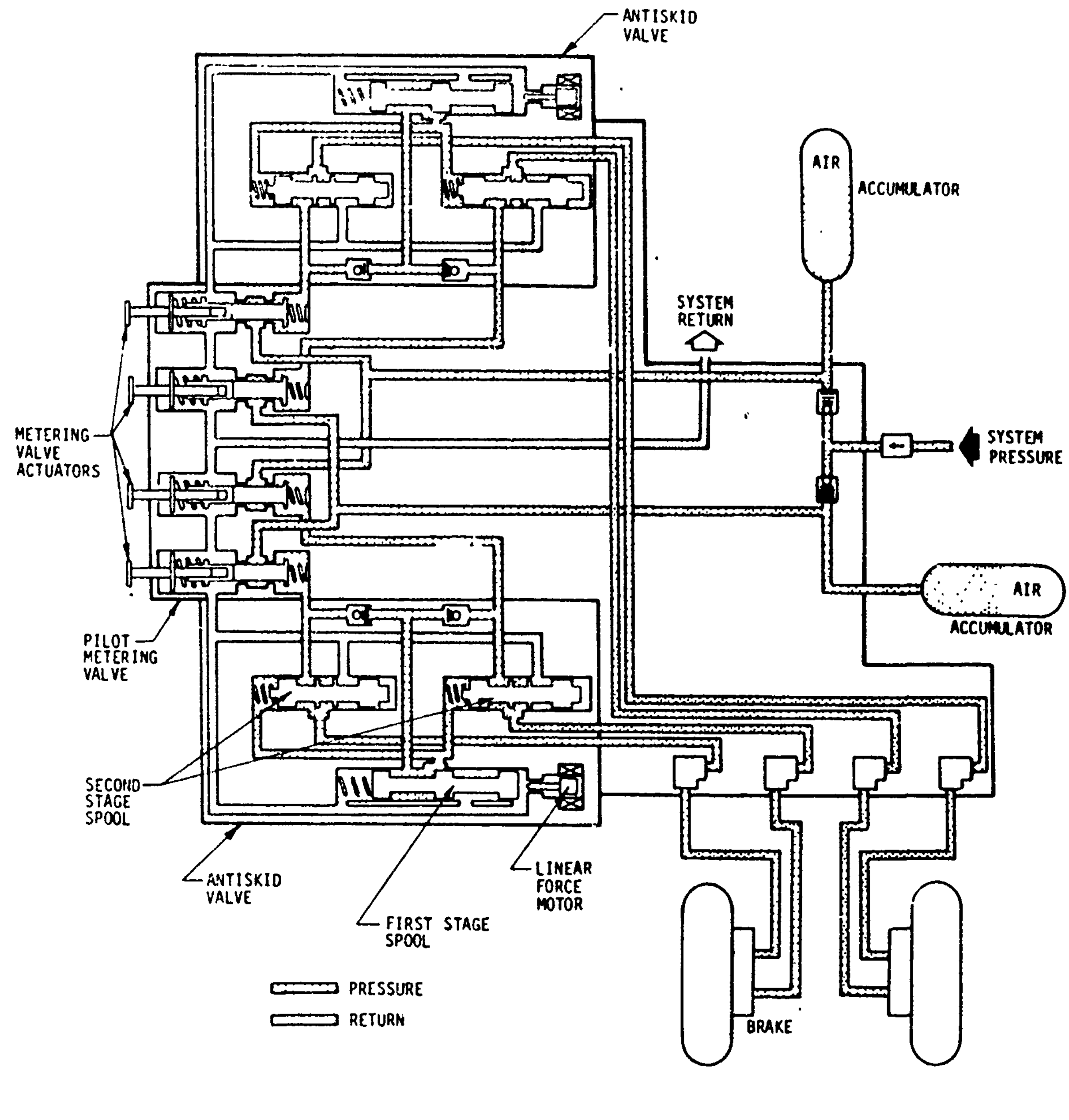

Figure 27.—Pilot Metering Valve and Antiskid Valve Assembly Schematic (Primary Hydraulic Circuits)

the pressure plate, rotors and stators into contact. This action creates a friction force which decelerates the wheel. Removal of pressure releases the brake allowing the wheel to free roll.

2. BRAKING SYSTEM CHARACTERISTICS

During the testing of the F-111, the characteristics of the brake hydraulic system and individual components were measured. The dynamic response of the hydraulic system is shown in Figures 28 and 29. Figure 28 is a typical system frequency response plot, while Figure 29 is a representative step response plot. Tables 11 and 12 compile the dynamic response results from various test conditions.

The pressure-current characteristic of the F-111 antiskid valve is shown in Figure 30. The effect of varying metered pressures is also depicted.

The pressure-volume curve of the F-111 brake is shown in Figure 31. The P-V characteristic was measured by externally connecting the two individual hydraulic chambers together. Consequently, the volume of both chambers were combined.

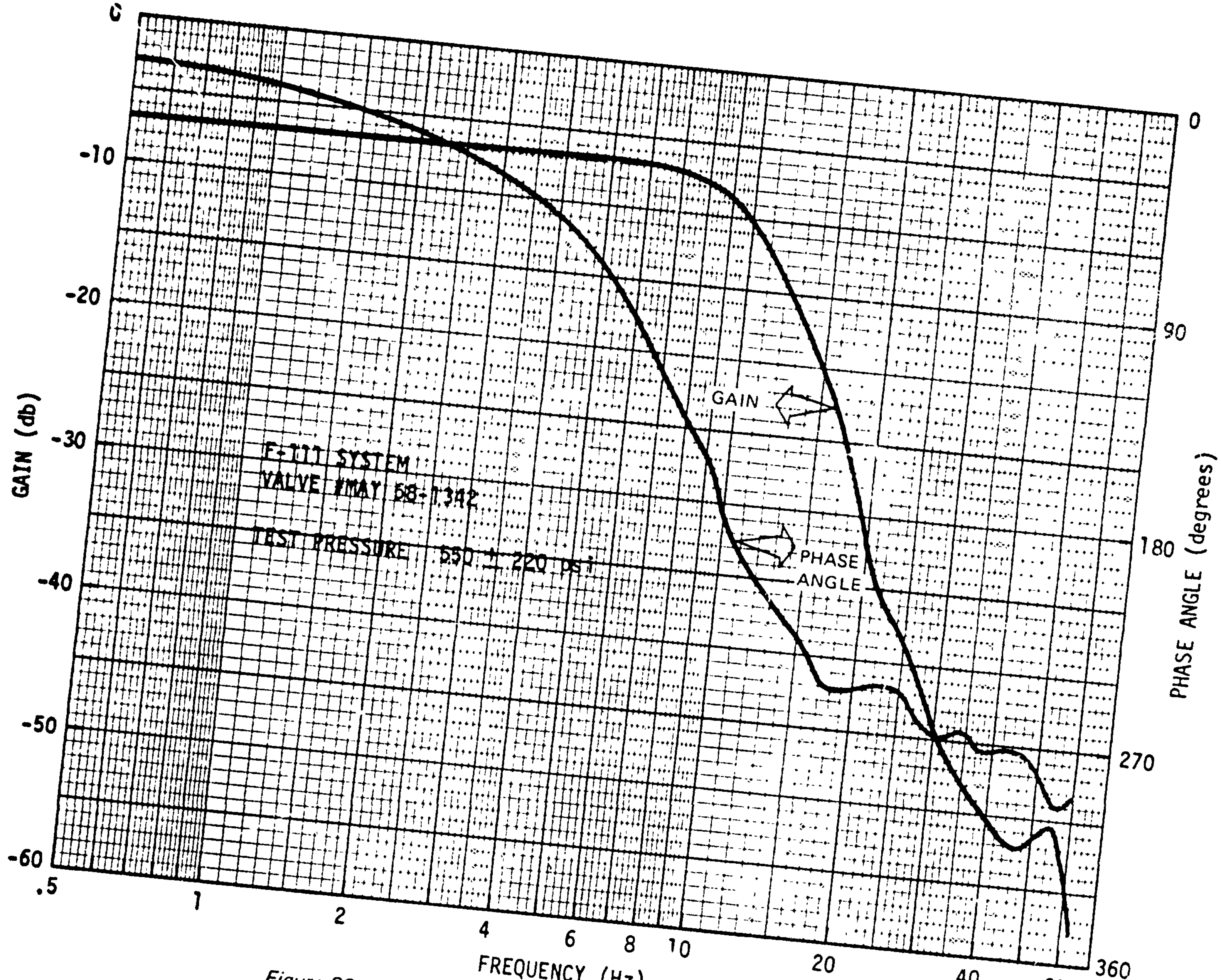

Figure 28.—F-111 Brake Hydraulic S

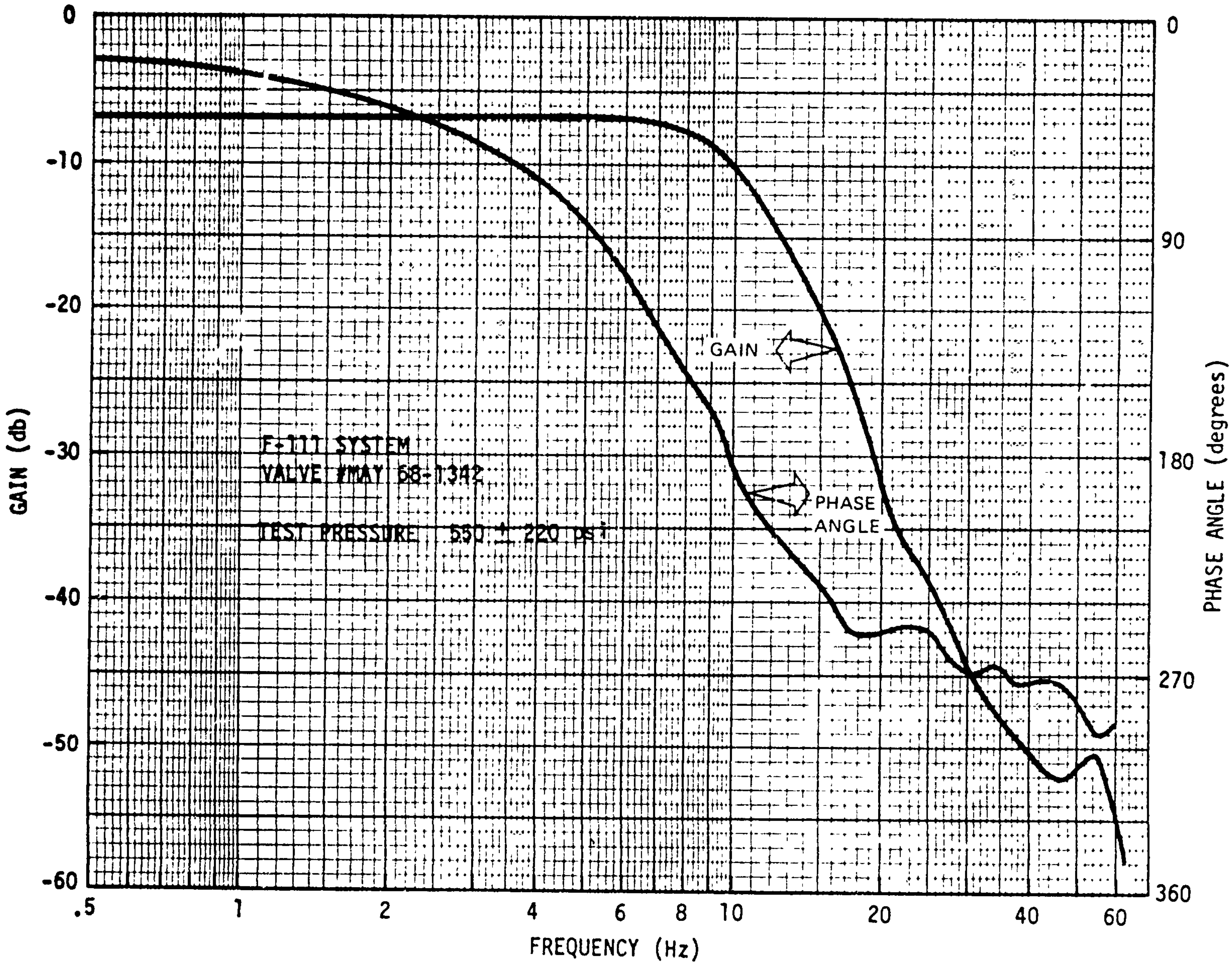

Figure 28.—F-111 Brake Hydraulic System Frequency Response

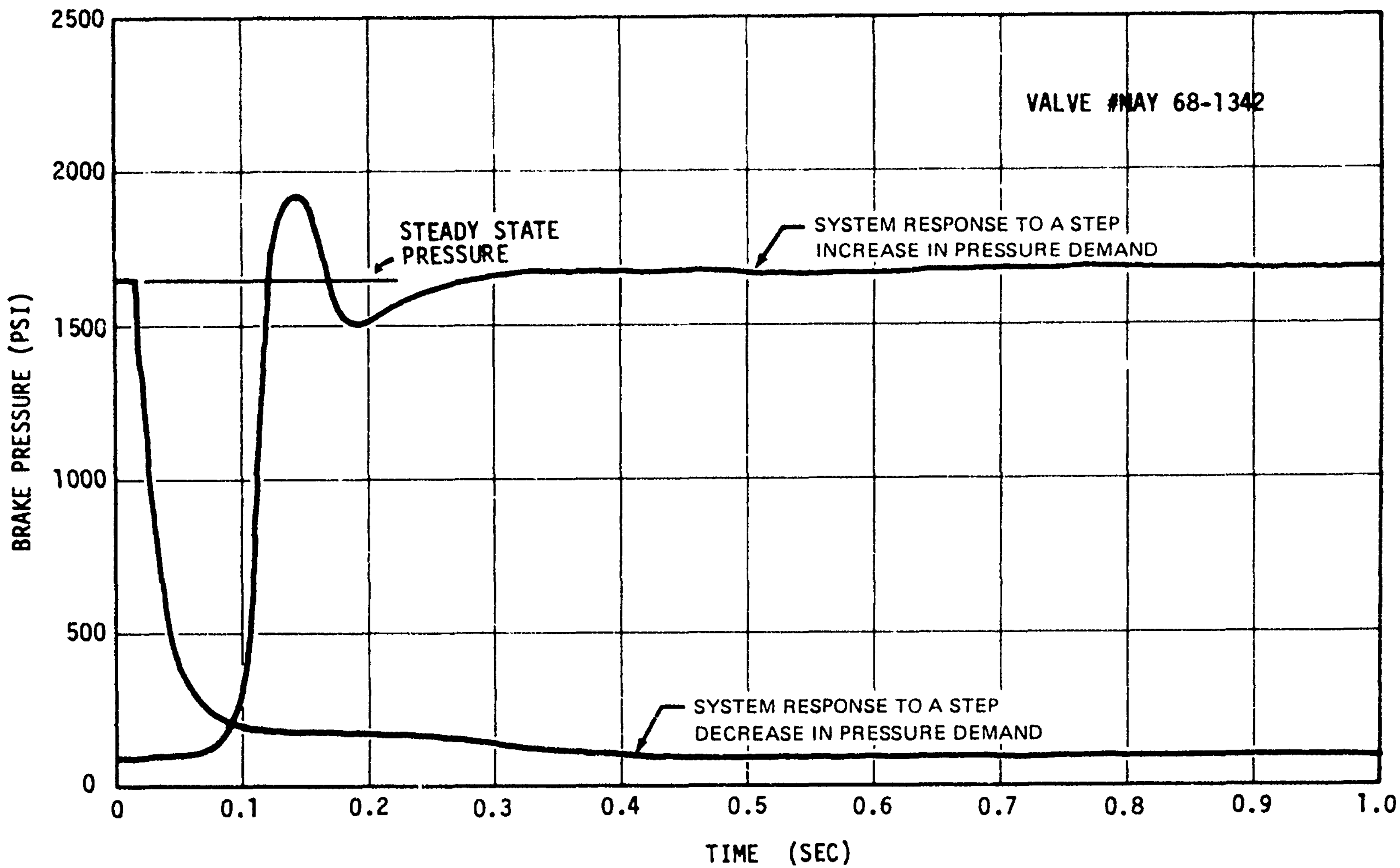

Figure 29.—F-111 Brake Hydraulic System Step Response

Table 11.—F-111 Frequency Response Data

TEST CONDITION	TEST PRESSURE -psi-	RESONANT POINT FREQUENCY OR -3db FREQUENCY (H_z)	GAIN AT RESONANCE OR -3db POINT (db)	PHASE ANGLE AT RESONANCE OR -3db (degrees)	FREQUENCY AT 90° PHASE ANGLE (H_z)
STANDARD HYDRAULIC CONFIGURATION					
ANTISKID VALVE #MAY 68-1342	550 ± 120	6.4	+1.0	122	4.7
	550 ± 200	5.4	+.5	90	5.4
	1100 ± 120	7.3	+4.5	97	7.0
	1100 ± 200	7.4	4.2	85	7.7
ANTISKID VALVE #AUG 67-72-E	550 ± 120	6.2	+3.5	88	6.3
	550 ± 200	5.5	+2.5	75	6.1
	1100 ± 120	6.3	+6.0	90	6.3
	1100 ± 200	6.7	+5.0	85	6.9

Table 12.—F-111 Step Response Data

TEST CONDITION	PRESSURE STEP CHANGE (PSI)	DELAY RESPONSE TIME (SEC)		RESPONSE TIME TO 80% OF PRESSURE CHANGE		PERCENTAGE PRESSURE OVERSHOOT OF STEP CHANGE	
		PRESSURE INCREASE	PRESSURE DECREASE	PRESSURE INCREASE	PRESSURE DECREASE	PRESSURE INCREASE	PRESSURE DECREASE
STANDARD HYDRAULIC CONFIGURATION							
ANTISKID VALVE #MAY 68-1342	0-1650	*.078	.016	.114	.057	16.4	0
	0-1490	*.047	.013	.120	.065	18.8	0
	0-825	*.088	.012	.143	.260	23.6	0
	330-1490	.022	.012	.052	.042	20.7	3.4
	330-1650	.017	.017	.055	.045	18.2	4.5
ANTISKID VALVE #AUG 67-72-E	0-1650	*.080	.012	.107	.055	28.5	0
	0-1490	*.080	.012	107	.060	38.9	0
	0-825	*.095	.012	.132	.225	46.7	0
	330-1490	.025	.012	.057	.040	44.8	6.0
	330-1650	.017	.012	.060	.042	38.6	5.3

* TIME TO 120 PSI

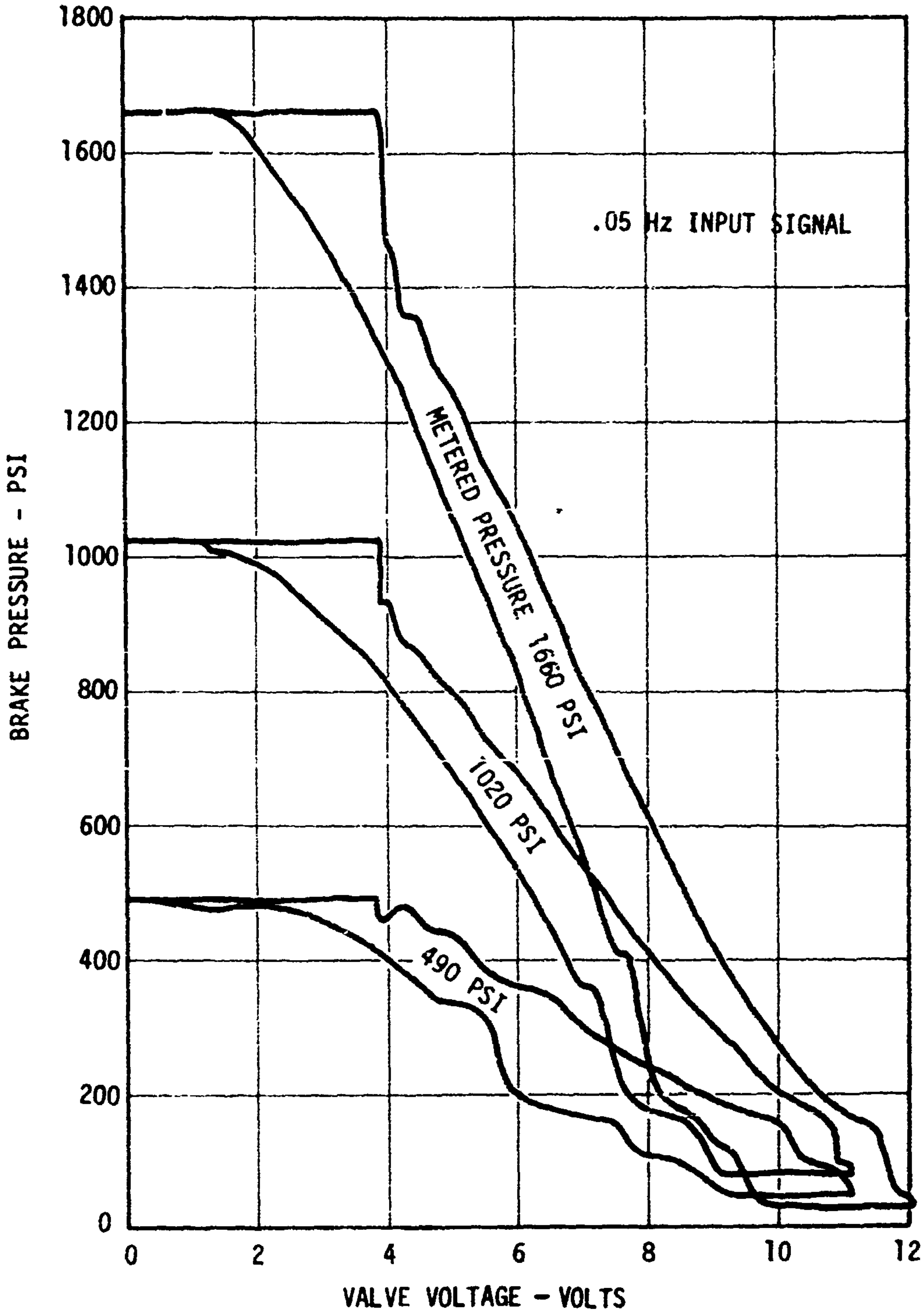

Figure 30.—F-111 Antiskid Valve Pressure - Current Characteristic

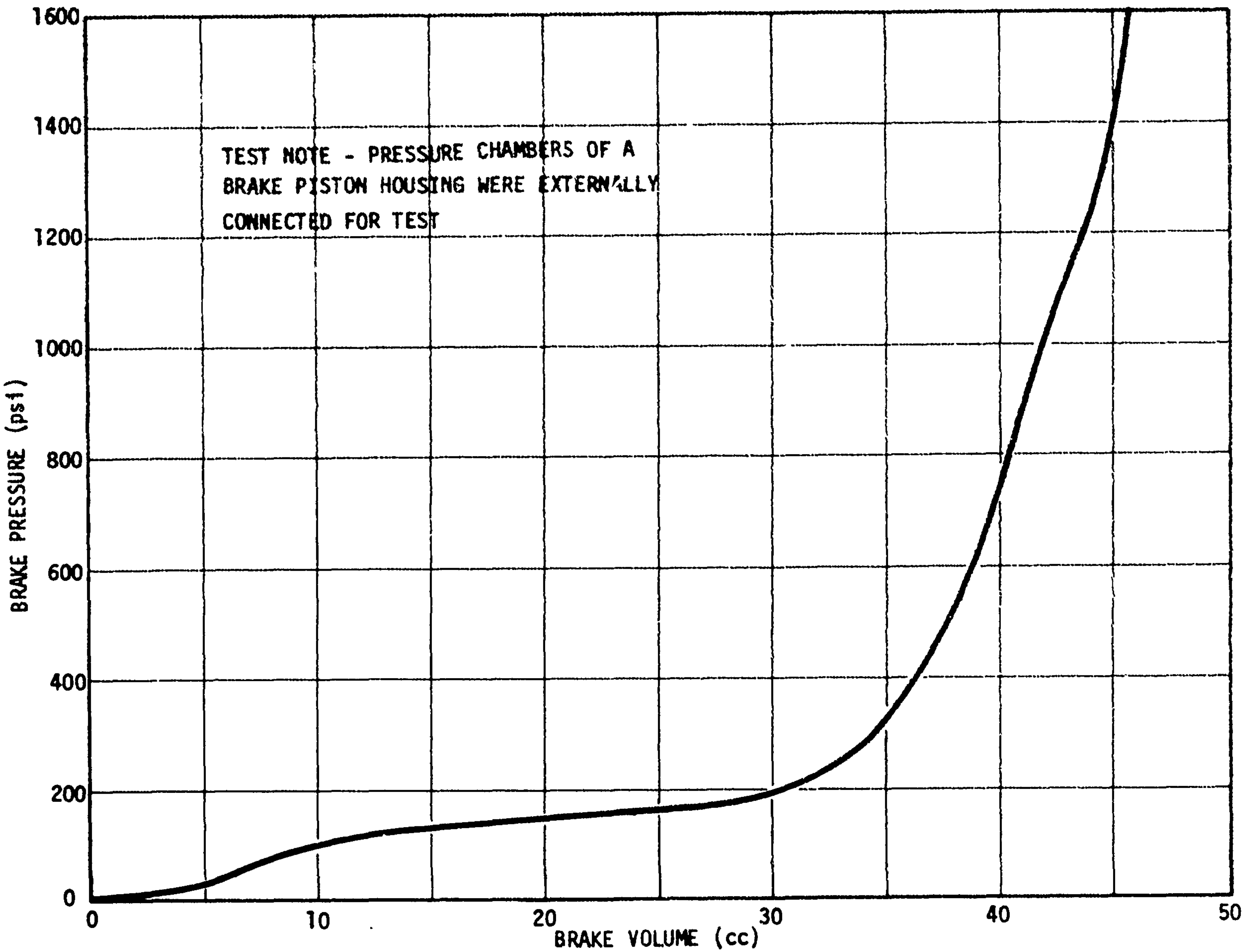

Figure 31.—F-111 Brake Pressure - Volume Characteristic

SECTION VI
REGION OF ANTISKID SYSTEM OPERATION ON MU-SLIP CURVE

The purpose of an antiskid system is to maximize the braking effort and at the same time prevent tire skidding. The actual level of braking attained is a direct result of the antiskid system design and implementation. During the sensitivity studies, an effort was made to measure how effective each antiskid system was at maximizing braking. To determine the level of operation, an oscilloscope was used to plot ground friction (mu) versus wheel slip The ideal antiskid system should operate at the peak of the mu-slip curve, maximizing friction and limiting slip. Actual systems operate over a region of slip and at friction levels lower than maximum. Early antiskid systems tend to operate over a wide range of slip, which results in a very low friction level. Present systems are designed to operate over a smaller slip region near the peak friction value.

The actual region of mu-slip operation is described for each antiskid system in the following paragraphs. Regions I, II, III, and IV, as depicted in Figure 32, will be used to define the operational characteristics of each system.

1. B-52H MARK I

The B-52H brake system is torque limited when ground friction is greater than .4 and/or the aircraft's landing weight is above 250,000 pounds. Under these conditions, the wheel operates on the front side of the mu-slip curve (Region I). As available ground mu drops or aircraft weight is lowered (torque limiting does not occur) skid activity will occur with the antiskid system operating in region I at high speed. Deeper skids occur as the aircraft slows (cycling from region I into regions II and III) until full wheel lockups (Region IV) occur at about 40 knots. From this point on, the wheel simply cycles between 0 and 100% slip (region I to IV).

2. KC-135 MARK II

The KC-135 Mark II antiskid system operates in regions II and III at all values of peak mu. During high speed operation, the system cycles in region II only. As the aircraft slows deeper skids occur with the system cycling into region III. As the antiskid system initiates brake releases, the wheel recovers from the high slip condition by cycling up the back side of the curve into region II.

3. F-111 GOODYEAR SYSTEM

The Goodyear antiskid system found on the F-111, allows the wheel to operate primarily in regions I and II at all peak available mu levels. However, as the aircraft slows the skid depth increases extending system operation into regions III and IV.

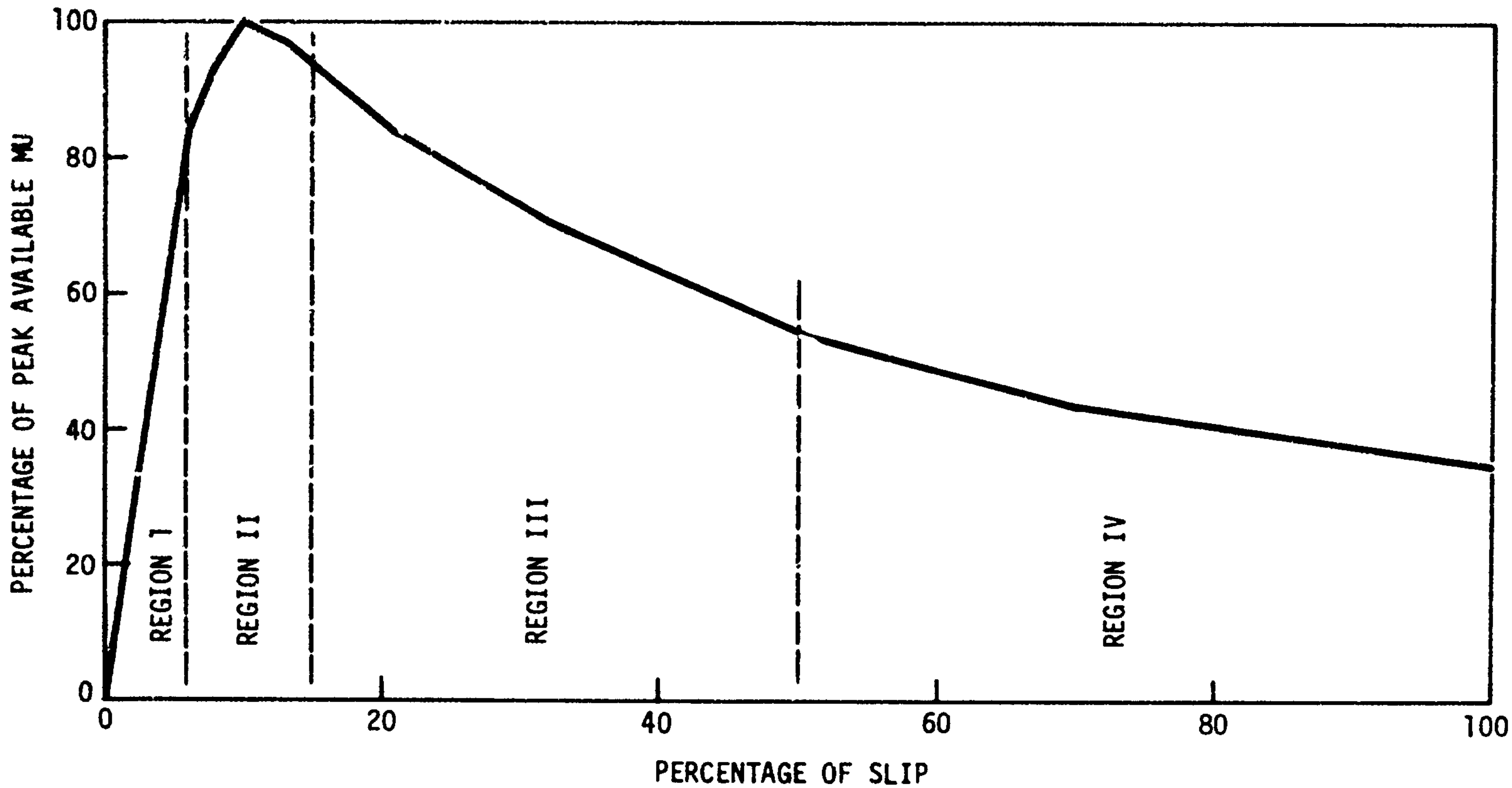

Figure 32.—Definition of Operating Regions on Mu-Slip Curve

SECTION VII
DETAILED SENSITIVITY STUDY TEST PROCEDURE AND SEQUENCE

1. TEST PROCEDURE

The sensitivity study of the braking segment consisted of nine separate system tests. The tests were implemented as the system parameters were varied, one at a time, to determine the sensitivity of aircraft performance to each parameter. The tests can be divided into three categories

- Stability studies
- Performance studies
- Hydraulic system studies.

The tests performed in each of these categories are outlined below.

A. STABILITY STUDIES (Test 1)

System stability is directly related to stopping performance in that severe instability will result in loss of braking and can present a serious safety hazard. In this study, the ability of a brake control system to contribute to the stability of the landing gear was evaluated. The stability margin of the system was determined by finding the damping required for stability.

The purpose of the test was to determine the contribution of the brake control system to landing gear oscillations. During a run, the brake torque was caused to peak from its nominal value to its maximum value numerous times during a stop. The timing was varied so that the steps would occur during all operational modes of the control system. The strut displacement was monitored to determine the influence of the control system on strut stability. Two gear frequencies were evaluated to cover the expected range of natural frequencies for the system. Gear damping was varied to find the point where the system becomes unstable.

The gear frequencies were changed by altering gear mass or gear compliance. The ability of the system to dampen gear oscillations for two different compliances and masses was assessed.

B. PERFORMANCE STUDIES

The brake system was evaluated under four different conditions chosen to provide a measure of its performance capability. These include airplane touchdown dynamics, stabilized landing, step mu change, and wet runway. Of the four tests, three fall into the general category of system adaptability to typical operating conditions. Icy or wet patches on an otherwise dry runway were simulated by the step mu test. Typical load changes encountered during high sink rate landings were simulated. Mu changes with speed as encountered on a wet runway were evaluated. The other condition covers the general category of stabilized performance.

1. Touchdown Dynamics (Test 2)

The purpose was to determine transient response upon touchdown. The test was initiated by applying the aircraft brakes at a speed V_A. During the run from speed V_A to V_B, vertical ground force was varied in a manner to simulate a typical touchdown load profile of the airplane being tested. The vertical ground force was restored to its full value when the braked-vehicle speed reached a value of V_B. Full pilot metered pressure was available during this and other runs, unless specifically mentioned otherwise.

2. Stabilized Landing (Test 3)

The purpose of these tests was to measure brake system efficiency under a stabilized braked condition. The tests determined a baseline performance for each system.

During the tests, the vehicle was braked at a preselected braked speed V_A. Braking was continued until the vehicle was brought to a full stop. During these tests, the peak available ground mu was held at a constant value throughout the entire run. This value was varied from one run to another to cover the entire range of available ground mu (0.05, 0.1, 0.2, 0.3, 0.4, 0.5, and 0.6).

3. Mu Steps (Test 4)

The purpose of this test was to measure brake system adaptability under adverse runway conditions. The test was designed to simulate sudden changes of available ground mu resulting from water puddles, icy patches, or the presence of tar strips.

The braking run proceeded for the first few seconds with a high available mu. Then the first of several mu step changes occurred. Each consisted of a pulse width of 750 milliseconds dropping the mu to 0.15. After each pulse, the mu was restored to its high value for 5 seconds. Thus, during the test, the system was subjected to several step changes so that its operation under a variety of conditions could be observed.

4. Wet Runway (Test 5)

The purpose of this test was to study system performance under adverse runway conditions. During the test, the value of peak available ground mu was made to vary from a low value at high speed to a high value at low speed. This relationship is representative of the available ground mu normally encountered on a wet runway. The value of mu at high speed was modified in some cases to allow the wheel ample ground friction to spin up the wheel.

C. HYDRAULIC SYSTEM STUDIES

1. Hydraulic System Response (Test 6 and 7)

Frequency response and step response tests were run on the brake hydraulic system. Frequency response tests were run over the frequency range of 0.5 to 50 Hz and at amplitudes of ± 100 psi and ± 200 psi. This test was conducted at mean pressure levels of 33% and 66% of supply pressure.

The step response curves consisted of the following steps indicated in percentage of supply pressure:

From	To
0	50
0	90
100	20
100	0
90	20

The input to both tests was valve current, and the output was the pressure at the brake.

2. Antiskid Valve Characteristics (Test 8)

Static pressure versus current curves were also run on the servo valve for each airplane at metered pressure levels of 33%, 66%, and 100% of supply.

3. Hydraulic System Pressure – Volume Characteristics (Test 9)

Pressure-volume characteristics were measured for each brake.

2. TEST SEQUENCE

The sequence of the tests is given in Table 13.

Table 13.—Test Sequence

CONDITION	TEST	VARIABLE CHANGES
AIRPLANE		
BASELINE AIRPLANE	1 - 9	---
1a - 1d	3,5	W, Iyy, V_I
1e - 1h	3,5	W, Iyy
2A & 2b	3,5	Iyy, L_A, L_B
3a - 3f	3,5	V_I
4a - 4e	3,5	C_L, C_D
4f - 4i	3,5	FEO, KE
5a & 5b	3,5	PILOT'S METERED PRESSURE
RUNWAY AND ENVIRONMENTAL SYSTEM		
1a - 1f	3,5	V_{wind}
2a & 2b	3,5	RHO
LANDING GEAR SYSTEM		
1a - 1d	3,5	$\mu \cdot \sigma$ SHAPE

SECTION VIII
PERFORMANCE INDICES

Tables 14 through 19 contain the numerical values of the performance indices for all of the aircraft tested. Listed for each test condition is the available friction (mu), airplane braking distance (X_A), perfect braking distance (X_p), and braking distance efficiency (η_s).

Table 14.—B-52 Baseline Braking Data

TEST CONDITION	Mu	X_p	X_a	η_s
TEST #2 TOUCHDOWN DYNAMICS	.6	618	1858	33.3
	.5	720	1864	38.6
	.4	867	1905	45.5
	.3	1100	2105	52.3
	.2	1527	4062	37.6
	.1	2594	6024	43.1
	.05	4214	8219	51.3
TEST #3 STABILIZED STOPS	.6	571	1779	32.1
	.55	619	1766	35.1
	.5	675	1754	38.5
	.45	743	1762	42.2
	.4	825	1775	46.5
	.35	929	1748	53.1
	.3	1063	1852	57.4
	.25	1242		
	.2	1497	3904	38.3
	.15	1887	4434	42.6
	.1	2574	5694	45.2
	.05	4209	7830	53.8
TEST #4 MU-STEP		720	1953	36.9
TEST #5 WET-RUNWAY		1985	3434	57.8

Table 15.—B-52 Sensitivity Test Data

Condition	Description	Mu	X_A	X_P	[illegible]
1a thru 1d	Test Conditions Not Consistent With Normal B-52 Operation		TESTS NOT RUN (SEE TEST NOTES)		
1e	Maximum Landing Weight Without VI				
	Stabilized Landing	0.6	2822	576	20.4
		0.4	2798	842	30.1
		0.2	2184	1573	56.5
		0.1	6784	2810	41.4
	Wet Runway		4226	2265	55.6
1f	High Landing Weight Without VI				
	Stabilized Landing	0.6	2278	574	25.2
		0.4	2288	856	36.5
		0.2	2985	1541	51.6
		0.1	4136	2710	44.2
	Wet Runway		3804	2143	56.3
1g	Low Landing Weight Without VI				
	Stabilized Landing	0.6	1517	565	37.5
		0.4	1519	817	53.8
		0.2	3564	1461	41.0
		0.1	5150	2476	48.1
	Wet Runway		3263	1875	57.6
1h	Minimum Landing Weight Without VI				
	Stabilized Landing	0.6	1246	564	45.4
		0.4	1475	805	54.7
		0.2	3216	1415	44.0
		0.1	4615	2353	51.0
	Wet Runway		3016	1746	57.6
2a	Forward Center of Gravity				
	Stabilized Landing	0.6	1794	571	31.8
		0.4	1810	825	45.6
		0.2	3710	1497	35.7
		0.1	5557	2574	46.0
	Wet Runway		3434	1886	57.8
2b	Aft Center of Gravity				
	Stabilized Landing	0.6	1796	571	31.8
		0.4	1790	825	46.1
		0.2	3188	1497	39.5
		0.1	5621	2574	45.8
	Wet Runway		3368	1986	59.0
3a	Brake Application Speed + 5 Kn				
	Stabilized Landing	0.6	1916	635	33.1
		0.4	1934	913	47.2
		0.2	4030	1636	40.6
		0.1	5815	2774	47.2
	Wet Runway		3584	2169	60.4
3b	Brake Application Speed + 10 Kn				
	Stabilized Landing	0.6	2116	701	33.2
		0.4	2109	1003	47.6
		0.2	4254	1778	41.8
		0.1	6105	2971	48.7
	Wet Runway		3802	2528	61.2
3c	Brake Application Speed + 20 Kn				
	Stabilized Landing	0.6	2418	845	34.5
		0.4	2470	1193	48.5
		0.2	4508	2067	45.9
		0.1	6390	3361	52.6
	Wet Runway		4168	2635	63.2

Table 15.—B-52 Sensitivity Data (Continued)

Condition	Description	MU	x_A	x_P	S
3d	Brake Application Speed + 30 Kn				
	Stabilized Landing	0.6	2755	954	36.1
		0.4	2866	1392	49.6
		0.2	4855	2557	48.6
		0.1	6890	3758	34.6
	Wet Runway		4550	2557	65.0
3e	Brake Application Speed - 5 Kn				
	Stabilized Landing	0.6	1633	511	31.2
		0.4	1625	741	45.7
		0.2	3466	1360	39.2
		0.1	5112	2574	46.4
	Wet Runway		3178	1835	31.8
3f	Brake Application Speed - 10 Kn				
	Stabilized Landing	0.6	1457	453	31.1
		0.4	1460	660	45.2
		0.2	3560	1224	37.1
		0.1	4967	2171	43.7
	Wet Runway		3027	1667	35.1
4a	No Spoilers				
	Stabilized Landing	0.6	1855	677	36.5
		0.4	2164	577	45.2
		0.2	4400	1770	40.2
		0.1	6640	3045	45.5
	Wet Runway		4130	2419	58.6
4b	80% Effective Spoilers				
	Stabilized Landing	0.6	1786	589	35.0
		0.4	1772	851	48.0
		0.2	3940	1543	39.2
		0.1	5676	2655	46.8
	Wet Runway		3567	2065	57.5
4c	60% Effective Spoilers				
	Stabilized Landing	0.6	1780	608	34.2
		0.4	1798	818	48.8
		0.2	4025	1592	40.0
		0.1	5806	2741	47.2
	Wet Runway		3635	2142	58.5
4d	40% Effective Spoilers				
	Stabilized Landing	0.6	1818	629	34.6
		0.4	1838	508	49.4
		0.2	4146	1646	55.7
		0.1	6036	2835	47.0
	Wet Runway		3796	2226	58.6
4e	20% Effective Spoilers				
	Stabilized Landing	0.6	1835	652	35.5
		0.4	1907	741	49.3
		0.2	4284	1705	39.8
		0.1	6204	2937	47.5
	Wet Runway		3930	2519	59.0
4f	120% Engine Idle Thrust				
	Stabilized Landing	0.6	1795	575	32.0
		0.4	1784	833	46.7
		0.2	4059	1823	37.5
		0.1	6143	2636	43.2
	Wet Runway		3598	2047	56.5
4g	110% Engine Idle Thrust				
	Stabilized Landing	0.6	1770	575	32.4
		0.4	1771	829	46.8
		0.2	3900	1510	38.7
		0.1	5751	2614	44.5
	Wet Runway		3477	2021	58.1

Table 15.—B-52 Sensitivity Data (Continued)

Condition	Description	MU	x_A	x_P	η_S
4h	90% Engine Idle Thrust				
	Stabilized Landing	0.6	1724	569	35 0
		0.4	1723	821	47 7
		0.2	3715	1484	40 0
		0.1	5280	2555	48 0
	Wet Runway		3386	1515	58 5
4i	80% Engine Idle Thrust				
	Stabilized Landing	0.6	1715	567	35 1
		0.4	1726	817	47 4
		0.2	3980	1471	41 1
		0.1	5082	2498	49 2
	Wet Runway		3274	1547	59 5
5a	75% of Full Metered Pressure				
	Stabilized Landing	0.6			
		0.4	TEST NOT RUN		
		0.2			
		0.1			
	Wet Runway				
5b	50% of Full Metered Pressure				
	Stabilized Landing	0.6			
		0.4	TEST NOT RUN		
		0.2			
		0.1			
	Wet Runway				
1a	5 Knot Wind				
	Stabilized Landing	0.6	1555	510	32 9
		0.4	1553	759	47 3
		0.2	3305	1323	40 0
		0.1	4723	2257	47 8
	Wet Runway		3010	1734	57 6
1b	10 Knot Wind				
	Stabilized Landing	0.6	1348	449	33 3
		0.4	1347	646	48 0
		0.2	2172	1156	41 7
		0.1	3199	1350	51 3
	Wet Runway		2515	1494	59 4
1c	15 Knot Wind				
	Stabilized Landing	0.6	1161	392	33 8
		0.4	1163	563	48 3
		0.2	2334	1001	42 9
		0.1	3488	1670	45 0
	Wet Runway		2127	1267	59 6
1d	20 Knot Wind				
	Stabilized Landing	0.6	984	340	34 2
		0.4	985	484	45 4
		0.2	1950	860	44 1
		0.1	2603	1420	54 5
	Wet Runway		1788	1071	59 9
1e	-5 Knot Wind				
	Stabilized Landing	0.6	2021	642	31 8
		0.4	2038	928	45 6
		0.2	4315	1692	39 2
		0.1	6356	2943	46 0
	Wet Runway		3936	2293	58 4
1f	-10 Knot Wind				
	Stabilized Landing	0.6	2297	714	31 1
		0.4	2291	1035	45 2
		0.2	4975	1893	38 1
		0.1	7332	3324	44 0
	Wet Runway		4565	2597	56 9

Table 15.—B-52 Sensitivity Data (Concluded)

Condition	Description	MU	X_A	X_p	S
2a	Hot Day High Altitude				
	Stabilized Landing	0.6	1851	876	31.0
		0.4	1857	840	45.2
		0.2	4279	1358	36.4
		0.1	6281	[illegible]	44.0
	Wet Runway		3906	2177	55.8
2b	Cold Day - Sea Level				
	Stabilized Landing	0.6	1628	564	34.6
		0.4	1650	808	48.8
		0.2	3419	1417	41.5
		0.1	4835	[illegible]	48.6
	Wet Runway		2965	1788	[illegible]
1a	Flat _ - - Peak				
	Stabilized Landing	0.6	1783	571	32.6
		0.4	1756	824	46.9
		0.2	3675	1495	40.7
		0.1	4911	2572	52.4
	Wet Runway		3408	1986	58.3
1b	Low Tire Heating				
	Stabilized Landing	0.6	1759	571	32.5
		0.4	1765	824	46.7
		0.2	3715	1495	40.2
		0.1	4927	2572	52.2
	Wet Runway		3468	1986	57.2
1c	Tire Inflation Pressure 80% of				
	Nominal Stabilized Landing	0.6	1774	571	32.2
		0.4	2208	824	37.5
		0.2	3810	1495	39.2
		0.1	5202	2572	49.4
	Wet Runway		3595	1985	53.2
1d	Tire Inflation Pressure 120% of				
	Nominal Stabilized Landing	0.6	1785	571	[illegible]
		0.4	1773	824	46.5
		0.2	3998	1495	37.8
		0.1	5055	2572	43.5
	Wet Runway		3558	1986	55.8

Table 16.—KC-135 Baseline Braking Data

TEST CONDITION	Mu	X_p	X_a	η_s
TEST #2 TOUCHDOWN DYNAMICS	.6	1367	1631	83.8
	.55	1461	1839	79.4
	.5	1571	1974	79.6
	.45	1701	2137	79.6
	.4	1859	2345	79.3
	.35	2057	2624	78.4
	.3	2310	3074	75.1
	.25	2644	3912	67.6
	.2	3111	5120	60.8
	.15	3817	6926	55.1
	.1	5030	10135	49.6
	.05	7793	---	---
TEST #3 STABILIZED STOPS	.6	1317	1552	84.9
	.55	1411	1703	82.9
	.5	1522	1893	80.4
	.45	1655	2064	80.2
	.4	1816	2283	79.5
	.35	2016	2569	78.5
	.3	2272	3040	74.7
	.25	2612	3884	67.3
	.2	3086	5108	60.4
	.15	3800	7082	53.7
	.1	5021	10885	46.1
	.05	7789	---	---
TEST #4 MU-STEP		1625	2260	71.9
TEST #5 WET-RUNWAY		4132	6205	66.6

Table 17.—KC-135 Sensitivity Test Data

Condition	Description	MU	X_A	X_P	T_S
1a	Maximum Landing Weight With VI				
	Stabilized Landing	0.6	4095	2148	82.5
		0.4	4110	2991	71.8
		0.2	6325	4975	78.6
		0.1	12999	7985	61.7
	Wet Runway		9505	6861	73.8
1b	High Landing Weight With VI				
	Stabilized Landing	0.6	2476	1745	70.5
		0.4	2746	2399	87.4
		0.2	5781	4055	70.0
		0.1	11665	6552	56.0
	Wet Runway		7677	5520	71.9
1c	Low Landing Weight With VI				
	Stabilized Landing	0.6	1310	1016	77.6
		0.4	1925	1403	72.9
		0.2	4561	2400	52.6
		0.1	5527	3946	41.4
	Wet Runway		4791	3128	65.3
1d	Minimum Landing Weight With VI				
	Stabilized Landing	0.6	1182	893	74.9
		0.4	1789	1235	69.0
		0.2	4986	2120	48.5
		0.1	10689	5509	32.8
	Wet Runway		4920	2760	61.1
1e	Maximum Landing Weight Without VI				
	Stabilized Landing	0.6	2290	1524	57.8
		0.4	2574	1895	78.3
		0.2	4188	3292	78.6
		0.1	9968	5629	56.4
	Wet Runway		7117	4888	68.7
1f	High Landing Weight Without VI				
	Stabilized Landing	0.6	1825	1322	72.4
		0.4	2176	1842	84.7
		0.2	4561	3209	70.4
		0.1	10211	5515	52.6
	Wet Runway		6654	4553	68.4
1g	Low Landing Weight Without VI				
	Stabilized Landing	0.6	1648	1312	79.6
		0.4	2451	1785	73.4
		0.2	5362	2951	55.0
		0.1	10941	4667	44.7
	Wet Runway		5986	3745	68.1
1h	Minimum Landing Weight Without VI				
	Stabilized Landing	0.6	2062	1309	78.8
		0.4	2888	1766	67.4
		0.2	6518	2816	52.1
		0.1	17834	4484	37.8
	Wet Runway		5957	5566	66.1
2a	Forward Center of Gravity				
	Stabilized Landing	0.6	1605	1363	84.7
		0.4	2402	1876	78.1
		0.2	5345	3178	85.6
		0.1	10442	8153	49.3
	Wet Runway		6007	4177	65.5
2b	Aft Center of Gravity				
	Stabilized Landing	0.6	1433	1270	86.2
		0.4	2205	1752	79.5
		0.2	4970	2989	60.1
		0.1	9365	4880	51.0
	Wet Runway		5765	3984	69.1

Table 17.—KC-135 Sensitivity Data (Continued)

Condition	Description	MU	X_A	X_p	r_S
3a	Brake Application Speed + 5 Kn.				
	Stabilized Landing	0.6	1669	1423	85 3
		0.4	2496	1553	80 2
		0.2	5518	3268	61 8
		0.1	11133	5269	47 5
	Wet Runway		6467	4368	67 5
3b	Brake Application Speed + 10 Kn.				
	Stabilized Landing	0.6	1790	1533	85 6
		0 4	2589	2694	80 9
		0.2	5719	3492	61 1
		0.1	11515	5586	48 3
	Wet Runway		6740	4586	68 0
3c	Brake Application Speed + 20 Kn.				
	Stabilized Landing	0.6	2024	1763	87 1
		0.4	2920	2386	81 7
		0.2	6346	3503	61 5
		0.1	12203	6080	49 8
	Wet Runway		7272	4582	68 5
3d	Brake Application Speed + 30 Kn.				
	Stabilized Landing	0.6	2521	2006	86 4
		0.4	3282	2690	82 0
		0.2	6745	4317	64 0
		0.1	13037	6553	50 6
	Wet Runway		7734	5552	65 7
3e	Brake Application Speed - 5 Kn.				
	Stabilized Landing	0.6	1441	1215	84 3
		0.4	2127	1682	79 1
		0.2	4759	2886	60 6
		0.1	10314	4750	46 1
	Wet Runway		6008	3513	65 1
3f	Brake Application Speed - 10 Kn.				
	Stabilized Landing	0.6	1332	1116	83 8
		0.4	1987	1552	78 1
		0.2	4318	2688	59.5
		0.1	9903	4477	45 2
	Wet Runway		5719	3672	64 2
4a	No Spoilers				
	Stabilized Landing	0.6	2149	1763	82 0
		0.4	3330	2428	68 8
		0.2	7520	4127	54 9
		0.1	14484	6749	46 6
	Wet Runway		8604	4694	54 6
4b	80% Effective Spoilers				
	Stabilized Landing	0.6	1628	1382	84 9
		0.4	2411	1806	75 0
		0.2	5453	3239	59 4
		0.1	11114	5277	47 5
	Wet Runway		6824	4294	65 8
4c	60% Effective Spoilers				
	Stabilized Landing	0.6	1755	1456	83 9
		0.4	2575	2007	77 8
		0.2	6130	3413	55 7
		0.1	11916	5567	46 7
	Wet Runway		[illegible]	4570	66 6
4d	40% Effective Spoilers				
	Stabilized Landing	0.6	1829	1542	84 3
		0.4	2767	2125	76 8
		0.2	6542	3614	56 2
		0.1	11833	5501	49 8
	Wet Runway		7277	4888	67 2

Table 17.—KC-135 Sensitivity Data (Continued)

Condition	Description	MU	X_A	X_P	η_S
4e	20% Effective Spoilers				
	Stabilized Landing	0.6	1976	1642	83.1
		0.4	3000	2263	75.4
		0.2	6833	3848	86.3
		0.1	13552	6289	46.4
	Wet Runway		8284	5568	65.0
4f	120% Engine Idle Thrust				
	Stabilized Landing	0.6	1868	1826	84.6
		0.4	2302	1832	79.6
		0.2	5174	3155	60.6
		0.1	12221	5156	42.2
	Wet Runway		6497	4241	65.3
4g	110% Engine Idle Thrust				
	Stabilized Landing	0.6	1870	1322	84.2
		0.4	2313	1824	78.9
		0.2	5612	3110	56.4
		0.1	11545	6087	44.1
	Wet Runway		6298	4206	66.8
4h	90% Engine Idle Thrust				
	Stabilized Landing	0.6	1578	1313	83.4
		0.4	2285	1807	79.1
		0.2	5249	3062	58.3
		0.1	10625	4986	46.6
	Wet Runway		6148	4086	66.6
4i	80% Engine Idle Thrust				
	Stabilized Landing	0.6	1543	1309	84.8
		0.4	2246	1799	80.1
		0.2	4880	3038	62.3
		0.1	10303	4883	47.3
	Wet Runway		5975	4059	67.9
5a	75% of Full Metered Pressure				
	Stabilized Landing	0.6	1698	1367	80.5
		0.4	2393	1859	77.7
		0.2	5368	3111	58.0
		0.1	*	5030	*
	Wet Runway		6818	4132	68.4
5b	50% of Full Metered Pressure				
	Stabilized Landing	0.6	2177	1367	62.8
		0.4	2298	1833	80.3
		0.2	5387	3111	57.8
		0.1	*	5080	[illegible] 3
	Wet Runway		6548	4132	68.1
1a	5 Knot Wind				
	Stabilized Landing	0.6	1465	1213	85.0
		0.4	2115	1671	79.0
		0.2	4873	2826	58.0
		0.1	9372	4354	48.6
	Wet Runway		5683	3745	66.0
1b	10 Knot Wind				
	Stabilized Landing	0.6	1366	1112	81.4
		0.4	1974	1827	77.4
		0.2	4301	2572	57.1
		0.1	8257	4109	49.8
	Wet Runway		4960	3363	67.9
1c	15 Knot Wind				
	Stabilized Landing	0.6	1254	1015	82.8
		0.4	1798	1390	77.3
		0.2	3881	2525	59.7
		0.1	7154	3601	51.6
	Wet Runway		4475	3012	67.3

*Braking Distance greater than Computer Limit (10,000 feet).

Table 17.—KC-135 Sensitivity Data (Concluded)

Condition	Description	MU	X_A	X_P	η_S
1d	20 Knot Wind				
	Stabilized Landing	0.6	1156	921	79.7
		0.4	1633	1260	77.1
		0.2	3341	2101	59.3
		0.1	6203	3299	53.2
	Wet Runway		3971	2656	67.9
1e	-5 Knot Wind				
	Stabilized Landing	0.6	1681	1394	84.4
		0.4	2421	1929	79.5
		0.2	5800	3297	56.8
		0.1	11929	5417	45.4
	Wet Runway		6512	4494	63.0
1f	-10 Knot Wind				
	Stabilized Landing	0.6	1821	1949	95.1
		0.4	2649	2139	80.7
		0.2	6364	3663	57.6
		0.1	13495	6041	44.8
	Wet Runway		7766	5021	64.7
2a	Hot Day - High Altitude				
	Stabilized Landing	0.6	1538	1326	86.2
		0.4	2329	1848	79.3
		0.2	5314	3221	60.6
		0.1	12397	5410	43.6
	Wet Runway		7216	4567	63.3
2b	Cold Day - Sea Level				
	Stabilized Landing	0.6	1537	1305	84.9
		0.4	2208	1772	80.3
		0.2	4662	2913	62.5
		0.1	9412	4563	48.2
	Wet Runway		5278	3700	70.1
1a	Flat μ - σ Peak				
	Stabilized Landing	0.6	1445	1367	94.6
		0.4	2068	1859	89.9
		0.2	4965	3111	62.6
		0.1	9687	5050	51.9
	Wet Runway		6068	4132	68.3
1b	Low Tire Heating				
	Stabilized Landing	0.6	1491	1367	91.7
		0.4	2119	1859	87.7
		0.2	4896	3111	63.5
		0.1	10101	5050	49.8
	Wet Runway		6239	4132	66.2
1c	Tire Inflation Pressure 80% of Nominal: Stabilized Landing				
		0.6	1539	1367	88.8
		0.4	2295	1859	82.4
		0.2	5531	3111	56.4
		0.1	9978	5050	50.4
	Wet Runway		6217	4132	66.5
1d	Tire Inflation Pressure 120% of Nominal: Stabilized Landing				
		0.6	1658	1367	82.4
		0.4	2470	1859	75.3
		0.2	5070	3111	61.4
		0.1	10327	5050	48.7
	Wet Runway		6020	4132	68.6

Table 18.—F-111 Baseline Braking Data

TEST CONDITION	Mu	X_p	X_a	η_s
TEST #2 TOUCHDOWN DYNAMICS	.6	1642	2192	74.9
	.55	1751	2358	74.3
	.5	1879	2648	71.0
	.45	2034	2925	69.5
	.4	2223	3349	66.4
	.35	2457	3893	63.1
	.3	2762	4885	56.5
	.25	3170	6099	52.0
	.2	3740	7958	47.0
	.15	4621	9555	48.5
	.1*	---	---	---
	.05*	---	---	---
TEST #3 STABILIZED STOPS	.6	1574	2111	74.6
	.55	1684	2304	73.1
	.5	1812	2556	70.9
	.45	1967	2861	68.8
	.4	2156	3300	65.3
	.35	2392	3909	61.2
	.3	2696	4857	55.5
	.25	3102	6315	49.1
	.2	3677	7966	46.2
	.15	455[illegible]	10054	45.3
	.1*	---	---	---
	.05*	---	---	---
TEST #4 MU-STEP		1955	2850	68.6
TEST #5 WET-RUNWAY		3528	6652	53.0

*See F-111 Test Note.

Table 19.—F-111 Sensitivity Data

Condition	Description	MU	X_A	X_P	n_S
1a	Maximum Landing Weight With VI				
	Stabilized Landing	0.6	2814	2217	77.1
		0.4	5137	3025	80.9
		0.2	8092	5112	65.2
		0.15	11551	6300	55.6
	Wet Runway		7532	4969	67.8
1b	High Landing Weight With VI				
	Stabilized Landing	0.6	2252	1895	84.1
		0.4	3543	2889	73.1
		0.2	8061	4555	54.6
		0.15	10180	5425	50.5
	Wet Runway		6806	4280	62.5
1c	Low Landing Weight With VI				
	Stabilized Landing	0.6	1880	1455	75.4
		0.4	3137	1992	63.5
		0.2	7305	3408	46.7
		0.15	8810	4230	41.5
	Wet Runway		5982	3255	54.4
1d	Minimum Landing Weight With VI				
	Stabilized Landing	0.6	1928	1558	69.4
		0.4	307[illegible]	1837	59.7
		0.2	7084	3182	44.5
		0.15	9125	3819	48.2
	Wet Runway		5980	2992	50.0
1e	Maximum Landing Weight Without VI				
	Stabilized Landing	0.6	1850	1330	82.4
		0.4	2817	2200	75.4
		0.2	6735	3848	56.5
		0.15	5708	4825	49.7
	Wet Runway		6012	3151	62.4
1f	High Landing Weight Without VI				
	Stabilized Landing	0.6	1875	1985	84.4
		0.4	[illegible]	2181	72.0
		0.2	7802	3775	51.7
		0.15	8864	4706	47.7
	Wet Runway		6078	3656	60.2
1g	Low Landing Weight Without VI				
	Stabilized Landing	0.6	2131	1510	73.7
		0.4	8537	2144	64.2
		0.2	7659	3655	47.5
		0.15	9485	4481	47.5
	Wet Runway		6268	3480	55.5
1h	Minimum Landing Weight Without VI				
	Stabilized Landing	0.6	2215	1566	70.8
		0.4	3506	2131	60.8
		0.2	7012	3388	45.9
		0.15	8801	4488	50.2
	Wet Runway		6812	3411	52.4
2a	Forward Center of Gravity				
	Stabilized Landing	0.6	2421	[illegible]34	71.6
		0.4	3891	2366	60.8
		0.2	9225	4004	43.4
		0.15	10556	4944	41.8
	Wet Runway		8018	3832	47.8
2b	Aft Center of Gravity				
	Stabilized Landing	0.6	198	1504	75.5
		0.4	3130	2065	66.5
		0.2	7873	3530	44.8
		0.15	9762	4381	44.5
	Wet Runway		6518	3404	52.2

Table 19.—F-111 Sensitivity Data (Continued)

Condition	Description	MU	X_A	X_P	n_S
3a	Brake Application Speed + 5 Kn				
	Stabilized Landing	0 6	2254	1691	73 0
		0 4	3948	2307	68 0
		0 2	8597	3302	46 3
		0 15		4814	
	Wet Runway		7104	3758	52 9
3b	Brake Application Speed + 10 Kn				
	Stabilized Landing	0.6	2396	1811	75 6
		0 4	3765	2461	63 3
		0.2	8116	4128	47 0
		0.15	10526	5072	48 2
	Wet Runway		7137	3874	58 7
3c	Brake Application Speed + 20 Kn.				
	Stabilized Landing	0.6	2667	2060	77 2
		0 4	4170	2778	66 6
		0.2	9449	4583	48.5
		0.15	11299	5588	49 5
	Wet Runway		7657	4407	57 6
3d	Brake Application Speed + 30 Kn.				
	Stabilized Landing	0.6	2990	2321	77 6
		0.4	4616	3106	67 3
		0.2	9874	5041	51 1
		0.15	11990	6099	50.3
	Wet Runway		8082	4841	58.8
3e	Brake Application Speed - 5 Kn.				
	Stabilized Landing	0.6	1901	1461	73 4
		0.4	3095	2008	64.3
		0.2	7978	3884	45.6
		0 15	9611	4297	44.7
	Wet Runway		6198	3826	58 6
3f	Brake Application Speed - 10 Kn.				
	Stabilized Landing	0.6	1845	1351	73 2
		0.4	2889	1864	63 6
		0.2	7315	3232	44.2
		0.15	9139	4039	44 2
	Wet Runway		5838	3107	53.2
4a	No Spoilers				
	Stabilized Landing	0.6	3060	2144	70 1
		0.4	4919	2844	58.8
		0.2	11334	5063	44 7
		0.15	13817	6307	45 6
	Wet Runway		*	8018	*
4b	80% Effective Spoilers				
	Stabilized Landing	0.6	2281	1686	73.6
		0.4	3408	2268	63 6
		0.2	8289	3678	46 8
		0 15	10807	4808	44 5
	Wet Runway		7163	3740	52 2
4c	60% Effective Spoilers				
	Stabilized Landing	0.6	2352	1749	74 4
		0.4	3707	2388	64 7
		0 2	8763	4102	46 8
		0.15	11296	5082	48 1
	Wet Runway		7542	3882	52 8
4d	40% Effective Spoilers				
	Stabilized Landing	0 6	2943	1888	73 1
		0.4	4050	2848	62 3
		0.2	9782	4367	44 8
		0.15	12020	5427	45 1
	Wet Runway		1930	4261	53 3

*Brake Control System would not function

Table 19.—F-111 Sensitivity Data (Continued)

Condition	Description	Mu	X_A	X_P	T_S
4e	20% Effective Spoilers				
	Stabilized Landing	0.6	2771	1987	71.7
		0.4	4384	2727	62.2
		0.2	10411	4681	45.0
		0.15	12868	5824	45.3
	Wet Runway		8720	4599	52.7
4f	120% Engine Idle Thrust				
	Stabilized Landing	0.6	2154	1587	74.4
		0.4	3345	2180	65.2
		0.2	8286	3748	45.2
		0.15	10856	4667	45.0
	Wet Runway		6625	3604	54.4
4g	110% Engine Idle Thrust				
	Stabilized Landing	0.6	2138	1581	73.5
		0.4	3246	2168	66.8
		0.2	8044	3712	46.1
		0.15	10644	4610	48.5
	Wet Runway		6785	3573	52.7
4h	90% Engine Idle Thrust				
	Stabilized Landing	0.6	2100	1568	74.7
		0.4	3204	2144	66.5
		0.2	7672	3642	47.5
		0.15	9322	4502	45.4
	Wet Runway		6605	3503	53.1
4i	80% Engine Idle Thrust				
	Stabilized Landing	0.6	2069	1562	75.5
		0.4	3149	2152	67.7
		0.2	7088	3608	51.1
		0.15	9301	4445	47.8
	Wet Runway		5968	3467	58.1
5a	75% of Full Metered Pressure				
	Stabilized Landing	0.6	1851	1574	85.0
		0.4	3055	2156	70.6
		0.2	7162	3677	51.3
		0.15	9109	4355	50.0
	Wet Runway		5850	3528	60.3
5b	50% of Full Metered Pressure				
	Stabilized Landing	0.6	2187	1514	72.0
		0.4	2547	2156	84.6
		0.2	6288	3677	58.5
		0.15	8489	4955	53.7
	Wet Runway		5321	3528	67.6
6a	5 Knot Wind				
	Stabilized Landing	0.6	1932	1464	75.8
		0.4	2964	2001	67.4
		0.2	6807	3396	49.5
		0.15	8928	4185	47.0
	Wet Runway		5642	3257	57.4
6b	10 Knot Wind				
	Stabilized Landing	0.6	1788	1346	75.3
		0.4	2746	1836	66.9
		0.2	6183	3103	50.2
		0.15	8003	3821	47.7
	Wet Runway		5066	2946	58.2
6c	15 Knot Wind				
	Stabilized Landing	0.6	1655	1232	74.5
		0.4	2546	1678	65.9
		0.2	5617	2825	50.3
		0.15	7112	3469	48.8
	Wet Runway		4644	2670	51.5

Table 19.—F-111 Sensitivity Data (Concluded)

Condition	Description	Mu	X_A	X_P	η_S
1c	20 Knot Wind				
	Stabilized Landing	0.6	1535	1124	73.3
		0.4	2335	1529	65.5
		0.2	3027	2560	50.9
		0.15	6221	3135	50.4
	Wet Runway		4188	2407	57.5
1e	-5 Knot Wind				
	Stabilized Landing	0.6	2279	1717	75.3
		0.4	3682	2554	65.7
		0.2	9065	4026	44.4
		0.15	11716	4957	42.7
	Wet Runway		7775	3862	49.7
1f	-10 Knot Wind				
	Stabilized Landing	0.6	2419	1851	76.5
		0.4	3885	2540	65.5
		0.2	9465	4362	46.1
		0.15	12320	5426	42.0
	Wet Runway		8304	4191	50.5
2a	Hot Day - High Altitude				
	Stabilized Landing	0.6	2168	1594	73.6
		0.4	3576	2206	65.3
		0.2	8317	3849	46.3
		0.15	11081	4827	43.8
	Wet Runway		7059	3149	53.1
2b	Cold Day - Sea Level				
	Stabilized Landing	0.6	2060	1547	75.1
		0.4	3149	2090	66.4
		0.2	7187	3458	48.1
		0.15	8806	4222	47.5
	Wet Runway		5741	3252	57.3
1a	Flat [illegible] Peak				
	Stabilized Landing	0.6	1955	1574	80.6
		0.4	3017	2156	71.5
		0.2	6485	3677	56.7
		0.15	8455	4555	53.9
	Wet Runway		5674	3528	62.2
[illegible]	Low Tire Heating				
	Stabilized Landing	0.6	2014	1574	78.2
		0.4	3089	2156	65.8
		0.2	[illegible]	3677	55.7
		0.15	8856	4555	61.4
	Wet Runway		5824	3528	60.6
3c	Tire Inflation Pressure 80% of Nominal. Stabilized Landing				
		0.6	2164	1574	72.7
		0.4	3422	2156	65.0
		0.2	7193	3677	51.1
		0.15	8925	4555	51.0
	Wet Runway		5560	3528	59.2
'c	Tire Inflation Pressure 120% of Nominal Stabilized Landing				
		0.6	2224	1574	70.8
		0.4	3717	2156	58.0
		0.2	9427	3677	39.0
		0.15	10347	4555	44.0
	Wet Runway		7817	3528	45.1

SECTION IX
STABILITY TEST RESULTS

1. STRUT DAMPING

In addition to the performance studies, stability studies were conducted to evaluate the tendency of a skid control system to contribute to the stability of the landing gear. These tests were designed to measure system ability to provide damping to the strut motion or, conversely, its tendency to couple in the oscillation, thereby causing divergence.

The fore-aft damping in the landing gear model was varied until the point of divergent gear oscillation was reached. The damping ratio was then determined at this point. By comparing the damping ratio of the baseline airplane to the damping ratio resulting from a parameter changes a qualitative statement may be made about the effect such a change would have on gear stability and stopping performance.

The damping ratio is a measure of how fast strut oscillations are attenuated. To determine the damping ratio a step torque input was made to the strut model. The resulting strut displacement was monitored as a function of time. The damping ratio was then calculated from

$$\zeta = \frac{\ell n \dfrac{A_O}{A(t)}}{2\pi n} \times 100\%$$

where:

ζ = damping ratio (in percent)

n = number of full strut oscillations

A_O = strut amplitude at time zero

$A(t)$ = strut amplitude after n strut oscillations.

The stability test conditions and results are listed in Tables 20 and 21 respectively for each aircraft.

Table 20.—Stability Test Conditions

TEST CONDITION	F-111			KC-135			B-52		
	ω	MS	KS	ω	MS	KS	ω	MS	KS
BASELINE	21.84	19.97	376,000	17.75	40.9	508,200	13.84	62.17	470,400
MAXIMUM STRUT FREQUENCY VARYING MASS	28	12.15	376,000	22.0	26.6	508,200	TESTS	NOT	RUN*
MINIMUM STRUT FREQUENCY VARYING MASS	10	95.24	376,000	12.0	89.4	508,200			
MAXIMUM STRUT FREQUENCY VARYING STIFFNESS	28	19.97	618,100	22.0	40.9	781,500			
MINIMUM STRUT FREQUENCY VARYING STIFFNESS	10	19.97	78,840	12.0	40.9	232,500			

* B-52H HAS A FIRST GENERATION ANTISKID SYSTEM WHICH IN NO WAY CONTRIBUTES TO SYSTEM STABILITY
ω GEAR NATURAL FREQUENCY IN HERTZ
MS STRUT MASS $lbf\text{-}sec^2/ft$
KS STRUT STIFFNESS lbf/ft

Table 21.—Stability Test Results

TEST CONDITION	DAMPING RATIO ** %		
	F-111	KC-135	B-52
BASELINE	5.76	0.67	TESTS NOT RUN
NOMINAL BASELINE DAMPING RATIO % USED FOR SENSITIVITY ANALYSIS	10.99	9.96	
MAXIMUM STRUT FREQUENCY VARYING MASS	0.34	0.70	
MINIMUM STRUT FREQUENCY VARYING MASS	*	0.71	
MAXIMUM STRUT FREQUENCY VARYING STIFFNESS	-0.413	-0.068	
MINIMUM STRUT FREQUENCY VARYING STIFFNESS	*	1.59	

**MINIMUM DAMPING RATIO IN PERCENT REQUIRED FOR SYSTEM STABILITY.

* SEE F-111 TEST NOTES

SECTION X
TEST NOTES

1. TORQUE LIMITED BRAKING

Torque limiting of the brake occurs when the available torque due to ground force is greater than the available brake torque. Under this condition, the wheel will not skid, but will decelerate at the same rate as the airplane. During such operation the antiskid system is inactive and no longer controls the wheel; full metered pressure is applied to the brake.

Torque limiting most often occurs on high mu runways with heavy gross weight airplanes. During this sensitivity study, torque limiting occurred in numerous test conditions. Table 22 lists those conditions for which torque limiting occurred during some portion of the braking run.

2. LOW FRICTION OPERATION - F-111

During the testing of the F-111, it was found that antiskid system operation was sporadic on runways with a coefficient of friction lower than .15. On such runways, the wheels would go into an immediate and deep skid. The system would only allow the wheel to partially recover before reapplying pressure, resulting in another skid. Such skid cycling would occur for several seconds before the antiskid system would automatically deenergize. In an effort to determine if the antiskid box was functioning properly, a number of tests were performed as specified in T.O. IF-111A-2-9-1, Section 6-1, Operational Checkout of Skid Control System. No malfunction of the box could be detected. As a result a lower mu limit of .15 instead of 0.05 was used during sensitivity testing to insure a uniform data base.

3. STRUT STABILITY F-111

During the strut stability testing, it was found that with frequencies below 16 Hertz the antiskid system operation was unstable. Testing revealed that strut oscillations were viewed as successive skids causing unnecessary reductions in brake pressure. Immediately after a skid, pressure was reapplied to a high level resulting in another skid. In this mode of operation, the strut would continue to oscillate undamped at about 10 to 11 hertz.

4. PRESSURE APPLICATION

The maximum metered pressure level on the B-52 and F-111 is controlled by a force limiting mechanism. At the time of testing, these mechanisms were unavailable. A similar mechanism which would allow the simulation of pilot brake pedal action (i.e., ramping on of brake pressure) was devised. However, a repeatable maximum metered pressure level could not be obtained. As a result it was necessary to eliminate the pilot action feature and start with high metered pressure. This method tended to cause an unusually deep skid at the start of each test run.

Table 22.—Torque Limited Cases (Tests la-ld only)

TEST CONDITION	TORQUE LIMITED RUNS (MU)*		
	F-111	KC-135	B-52
BASELINE	*	*	.23 thru .6
1a MAXIMUM LANDING WEIGHT	.4, thru .6	.4, thru .6	.15 thru .6
1b HIGH INTERMEDIATE LANDING WEIGHT	.6	.6	.2, thru .6
1c LOW INTERMEDIATE LANDING WEIGHT	*	*	.4, thru .6
1d MINIMUM LANDING WEIGHT	*	*	.35 thru .6

* NORMAL ANTISKID SYSTEM ACTIVITY

5. BASELINE DATA VARIATION – KC-135

During the sensitivity testing of the KC-135, variations in the baseline braking distance were noted. Normal simulator braking distance repeatability is about 1%. The KC-135 however, exhibited an average distance variation of about ± 4.5%. Extensive testing revealed that the antiskid valve pressure - current characteristic changed with operating history, as shown in Figure 33. The changing shape of the curve effects system response and ultimately braking distance.

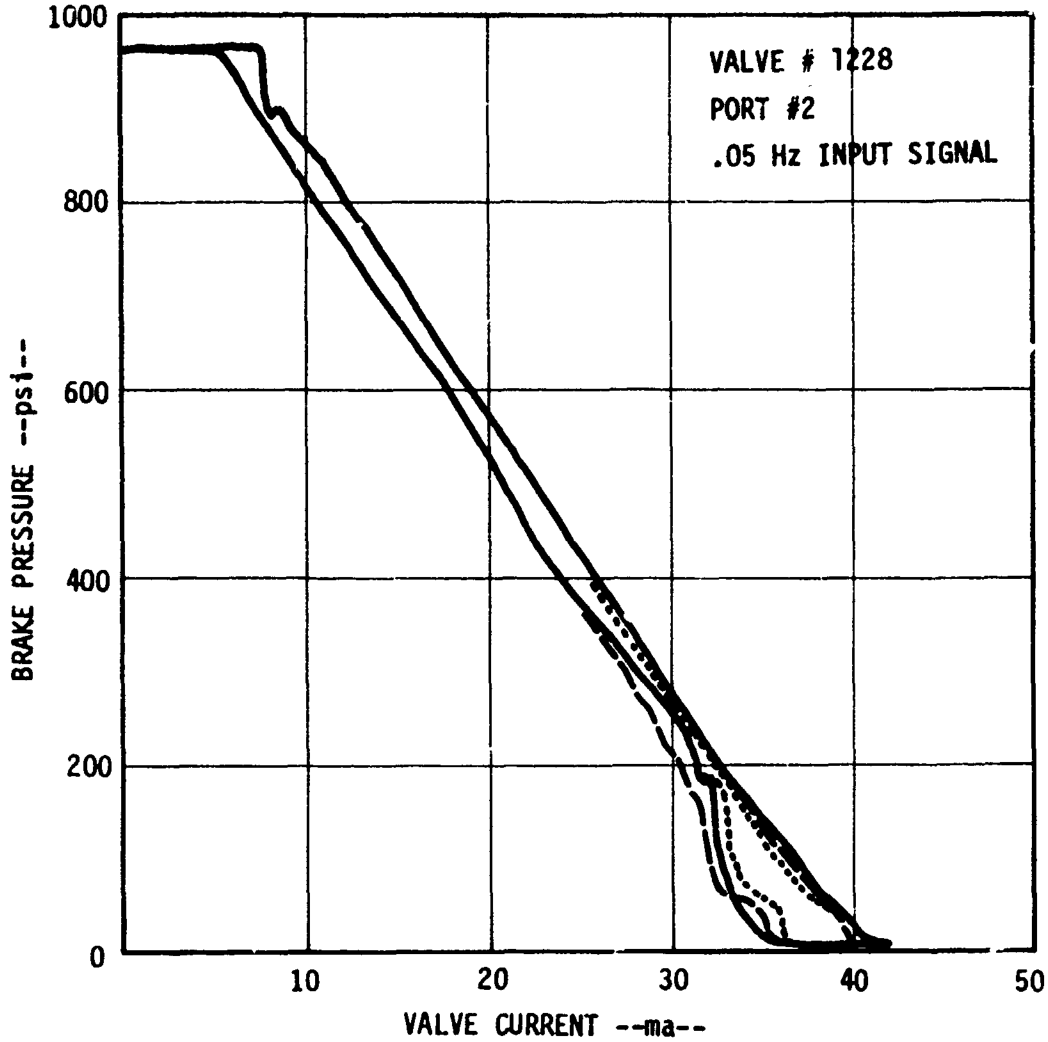

Figure 33.—Variable KC-135 Valve Response

SECTION XI
PARAMETER RATINGS

The following tables present the baseline braking distance percentages for frictional values of 0.6, 0.4, 0.2, and 0.1. Also shown in the parameter rating index (PRI) for all test conditions. Table 23 summarizes the percentages for all aircraft studied and lists the composite PRI. Tables 24 through 26 contain individual PRI values for the B-52, KC-135 and F-111.

Table 23.—Summary of Parameter Ratings

TEST CONDITION	BASELINE BRAKING DISTANCE (DRY - STABILIZED LANDINGS)												PRI
	Mu = 0.6			0.4			0.2			0.15	0.1		
	B-52	KC-135	F-111	B-52	KC-135	F-111	B-52	KC-135	F-111	F-111	B-52	KC 135	
1a. Maximum Weight with VI	*	204	136	*	180	113	*	124	102	113	*	.9	43 88
1b. High Weight With VI	*	160	107	*	120	107	*	113	101	107	*	107	15 25
1c. Low Weight with VI	*	84	94	*	84	95	*	89	92	89	*	88	10.63
1d. Minimum Weight with VI	*	76	91	*	78	93	*	86	89	81	*	98	13.50
1e. Maximum Weight without VI	158	148	91	158	104	98	71	82	85	97	119	92	23 42
1f. High Weight without VI	128	118	89	129	95	92	77	89	92	98	108	94	13 08
1g. Low Weight without VI	85	106	101	86	106	101	91	105	96	94	90	96	6 75
1h. Minimum Weight without VI	70	130	105	83	97	106	82	84	98	88	81	96	13 50
2a. Forward Center of Gravity	101	104	115	102	105	118	97	105	116	103	98	96	6.50
2b Aft Center of Gravity	101	95	94	101	97	95	97	97	99	97	99	98	3 67
3a. Brakes on Speed +5 kts.	108	108	107	109	107	108	103	104	105	—	103	102	5 82
3b. Brakes on Speed +10 kts.	119	115	113	119	113	114	109	112	110	105	107	106	11 83
3c. Brakes on Speed +20 kts.	136	130	126	139	128	126	115	124	119	112	112	112	23 25
3d. Brakes on Speed +30 kts.	155	150	142	161	144	140	124	132	124	119	120	120	35 92
3e Brakes on Speed -5 kts.	92	93	94	92	93	94	89	93	95	96	90	95	7 00
3f Brakes on Speed -10 kts.	82	86	87	82	87	89	85	89	92	91	87	91	12 75
4a. No Spoilers	104	130	145	122	155	149	113	147	142	131	117	133	33 50
4b. 80 Effective Spoilers	100	105	07	100	106	105	101	107	105	107	100	102	3 75
4c. 60% Effective Spoilers	101	112	111	101	113	112	103	120	110	112	102	109	8 83
4d. 40 Effective Spoilers	102	118	120	104	121	123	106	128	122	120	106	109	14.92
4e 20% Effective Spoilers	103	127	131	107	131	133	110	134	131	128	109	125	22 42
4f 120 Engine Idle Thrust	101	101	101	01	101	01	104	101	104	108	108	112	3.58
4g 110% Engine Idle Thrust	99	101	101	100	101	98	100	108	10[illegible]	106	101	106	2 00
4h 90% Engine Idle Thrust	97	101	99	97	100	97	95	103	96	99	93	98	2 75
4i. 80% Engine Idle Thrust	96	99	98	97	98	95	92	96	89	93	89	95	5 25
5a 75% Full Metered Pressure	●	109	88	●	105	93	●	105	90	91	●	+	8 14
5b. 50% Full Metered Pressure	●	140	104	●	101	77	●	105	79	84	●	+	15 71
1a 5 Knot Wind	87	94	91	88	93	90	85	95	85	89	83	86	11 17
1b 10 Knot Wind	76	88	85	76	86	83	71	88	78	80	67	76	20.50
1c. 15 Knot Wind	65	79	78	66	79	77	60	76	71	71	55	66	29 75
1d 20 Knot Wind	56	14	73	55	72	71	50	69	63	62	46	57	37 67
1e. -5 Knot Wind	114	106	108	115	106	109	111	114	114	117	112	110	11 53
1f. -10 Knot Wind	129	117	115	129	116	117	127	125	119	129	133	124	23 33
2a. Hot Day	104	99	103	105	102	102	110	104	104	110	110	114	5 75
2b Cold Day	92	99	98	93	97	95	81	91	90	88	85	87	8 17
1a. Flat Mu-Slip Peak	99	93	[illegible]	99	91	91	94	97	81	84	86	89	8 58
1b. Low Tire Heating	99	96	95	99	93	94	95	96	86	88	87	93	6 58
1c. 80 Tire Inflation Pressure	[illegible]	99	102	124	99	104	98	104	90	89	91	92	6 33
1d 120% Tire Inflation Pressure	100	107	105	100	108	113	101	99	118	103	104	95	6.42

*Test condition not consistent with B-52 operational procedures.

●Test not run

-Brake Control System would not function.

+Braking distance greater than computer limit

Table 24.—B-52H Parameter Ratings

RANK	TEST CONDITION	DESCRIPTION	PARAMETER RATING INDEX
1	1d	+20 KNOT WIND	48.25
2	1a	MAXIMUM LANDING WEIGHT	41.00
3	3d	BRAKE APPLICATION SPEED +30 KNOTS	40.00
4	1c	+15 KNOT WIND	38.50
5	1f	-10 KNOT WIND	29.50
6	1b	+10 KNOT WIND	27.50
7	3c	BRAKE APPLICATION SPEED + 20 KNOTS	25.50
8	1b	HIGH INTERMEDIATE LANDING WEIGHT	22.00
9	1d	MINIMUM LANDING WEIGHT	21.00
10	1f	BRAKE APPLICATION SPEED -10 KNOTS	16.00
11	1a	+5 KNOT WIND	14.25
12	4a	NO SPOILERS	14.00
13	3b	BRAKE APPLICATION SPEED +10 KNOTS	13.50
14	1e	-5 KNOT WIND	13.00
15	1c	LOW INTERMEDIATE LANDING WEIGHT	12.00
16	2b	COLD DAY	10.75
17	3e	BRAKE APPLICATION SPEED -5 KNOTS	9.25
18	1c	TIRE INFLATION PRESSURE 80% OF NORMAL	8.75
19	2a	HOT DAY	7.50
20	4e	20% EFFECTIVE SPOILERS	7.25
21	4i	80% ENGINE IDLE THRUST	6.30
22	3a	BRAKE APPLICATION SPEED +5 KNOTS	5.75
23	1a	FLAT MU-SLIP PEAK	5.50
24	1b	LOW TIRE HEATING	5.00
25	4d	40% EFFECTIVE SPOILERS	4.50
	4h	90% ENGINE IDLE THRUST	4 50
27	4f	120% ENGINE IDLE THRUST	3.50
28	2a	FOREWARD CENTER OF GRAVITY	2.00
29	4c	60% EFFECTIVE SPOILERS	1.75
	2b	AFT CENTER OF GRAVITY	1.50
31	1d	TIRE INFLATION PRESSURE 120% OF NORMAL	1.25
32	4g	110% ENGINE IDLE THRUST	.50
33	4b	80% EFFECTIVE SPOILERS	.25

Table 25.—KC-135 Parameter Ratings

RANK	TEST CONDITION	DESCRIPTION	PARAMETER RATING INDEX
1	1a	MAXIMUM LANDING WEIGHT W/VI	71.75
2	4a	NO SPOILERS	43.25
3	3d	BRAKE APPLICATION SPEED + 30 KNOTS	36.50
4	1d	+ 20 KNOT WIND	32.00
5	4e	20% EFFECTIVE SPOILERS	29.25
6	1c	+15 KNOT WIND	25.00
	1b	HIGH INTERMEDIATE LANDING WEIGHT W/VI	25.00
8	3c	BRAKE APPLICATION SPEED + 20 KNOTS	23.50
9	1f	-10 KNOT WIND	20.50
10	1e	MAXIMUM LANDING WEIGHT W/O VI	19.50
11	4d	40% EFFECTIVE SPOILERS	19.00
12	1d	MINIMUM LANDING WEIGHT W/VI	15.50
	1b	+ 10 KNOT WIND	15.50
14	5b	50% OF FULL METERED PRESSURE	15.33
15	1c	LOW INTERMEDIATE LANDING WEIGHT W/VI	13.75
16	4c	60% EFFECTIVE SPOILERS	13.50
17	1h	MINIMUM LANDING WEIGHT W/O VI	13.25
18	3f	BRAKE APPLICATION SPEED - 10 KNOTS	12.00
19	3b	BRAKE APPLICATION SPEED + 10 KNOTS	11.50
20	1f	HIGH INTERMEDIATE LANDING WEIGHT W/O VI	10.00
21	1e	-5 KNOT WIND	9.00
22	1a	+5 KNOT WIND	8.00
23	1a	FLAT MU-SLIP PEAK	7.50
24	2b	COLD DAY	6.50
	3e	BRAKE APPLICATION SPEED - 5 KNOTS	6.50
26	5a	75% OF FULL METERED PRESSURE	6.33
27	2b	AFT CENTER OF GRAVITY	5.75
28	1b	LOW TIRE HEATING	5.50
29	2a	HOT DAY	5.25
	1d	TIRE INFLATION PRESSURE 120% OF NORMAL	5.25
	3a	BRAKE APPLICATION SPEED + 5 KNOTS	5.25
	1g	LOW INTERMEDIATE WEIGHT W/O VI	5.25
33	4b	80% EFFECTIVE SPOILERS	5.00
34	2a	FORWARD CENTER OF GRAVITY	4.50
35	4g	110% ENGINE IDLE THRUST	4.00
36	4f	120% ENGINE IDLE THRUST	3.75
37	1c	TIRE INFLATION PRESSURE 80% OF NORMAL	3.50
38	4i	80% ENGINE IDLE THRUST	3.00
39	4h	90% ENGINE IDLE THRUST	1.50

Table 26.—F-111 Parameter Ratings

RANK	TEST CONDITION	DESCRIPTION	PARAMETER RATING INDEX
1	4a	NO SPOILERS	43.25
2	1d	20 KNOT WIND	32.75
3	3d	BRAKE APPLICATION SPEED + 30 KNOTS	31.25
4	4e	20% EFFECTIVE SPOILERS	30.75
5	1c	15 KNOT WIND	25.75
6	4d	40% EFFECTIVE SPOILERS	21.25
7	3c	BRAKE APPLICATION SPEED + 20 KNOTS	20.75
8	1f	-10 KNOT WIND	20.00
9	1b	10 KNOT WIND	18.50
10	1a	MAXIMUM LANDING WEIGHT W/VI	16.00
	5b	50% OF FULL METERED PRESSURE	16.00
2	2a	FORWARD CENTER OF GRAVITY	13.00
13	1a	FLAT MU-SLIP PEAK	12.75
14	1e	-5 KNOT WIND	12.00
15	1d	MINIMUM LANDING WEIGHT W/VI	11.50
16	4c	60% EFFECTIVE SPOILERS	11.25
	1a	5 KNOT WIND	11.25
18	3b	BRAKE APPLICATION SPEED + 10 KNOTS	10.50
19	3f	BRAKE APPLICATION SPEED - 10 KNOTS	10.25
20	1d	TIRE INFLATION PRESSURE 120% OF NORMAL	9.75
	1e	MAXIMUM LANDING WEIGHT W/VI	9.75
22	5a	75% OF FULL METERED PRESSURE	9.50
23	1b	LOW TIRE HEATING	9.25
24	1c	LOW INTERMEDIATE WEIGHT W/VI.	7.50
25	2b	COLD DAY	7.25
	1f	HIGH INTERMEDIATE WEIGHT W/O VI	7.25
27	1c	TIRE INFLATION PRESSURE 80% OF NORMAL	6.75
28	3a	BRAKE APPLICATION SPEED + 5 KNOTS	6.67
29	1h	MINIMUM LANDING WEIGHT W/O VI.	6.25
	4i	80% ENGINE IDLE THRUST	6.25
31	4b	80% EFFECTIVE SPOILERS	6.00
32	1b	HIGH INTERMEDIATE WEIGHT W/VI	5.50
33	3e	BRAKE APPLICATION SPEED - 5 KNOTS	5.25
34	2a	HOT DAY	4.75
35	2b	AFT CENTER OF GRAVITY	3.75
36	4f	120% ENGINE IDLE THRUST	3.50
37	1g	LOW INTERMEDIATE WEIGHT W/O VI	3.00
38	4g	110% ENGINE IDLE THRUST	2.50
39	4h	90% ENGINE IDLE THRUST	2.25

SECTION XII
CALCULATION OF PI TERMS

Tables 27, 28, and 29 contain information needed to calculate various pi terms. The data consists of baseline values as well as values used in the brake system simulation parametric study. Tables 30 through 32 show the actual calculation steps to obtain pi terms for each condition and all airplane models. The calculations for π_1, π_2, and π_3 are straightforward. For π_4 calculations, the term F_e was obtained using the following relationship:

$$F_e = F_{eo} + \frac{KE}{2} (v + v_{stop})$$

where:

F_{eo}	=	engine idle thrust at zero velocity
KE	=	change of idle thrust with velocity
v_{stop}	=	velocity at which stopping distance calculation was stopped on the simulator.

Table 27.—Baseline Values Used in Airplane Simulation and Prediction Model

Airplane Parameter		Airplane		
Symbol	Units	B-52	KC-135	F-111
C_D	---	.321	.202	.237
C_L	---	.305	.310	.280
Feo	lbf	4800	2400	904
KE	lbf-sec/ft	-10.65	-5.825	-1.258
	$lb\text{-}sec^2/ft^4$	.00238	.00238	.00238
V	fps	152	209	219.8
V_{stop}	fps	24	24	24
W	lbf	290000	185000	57000

Table 28.—Parametric Study Data

Test Condition and Parameter Changed	Airplane Model		
	B-52	KC-135	F-111
Airplane Parameters			
1a Maximum Landing Weight			
WA	450000	300000	80000
VI	[1]	267.3	261.5
IYY x 10^{-6}	8.16	4.927	.225
1b High Landing Weight			
WA	370000	242500	68500
VI	[1]	240.8	241.5
IYY x 10^{-6}	6.87	4.344	.217
1c Low Landing Weight			
WA	245000	142500	52900
VI	[1]	183.3	211.0
IYY x 10^{-6}	4.87	3.330	.205
1d Minimum Landing Weight			
WA	200000	125000	48800
VI	[1]	171.7	202.3
IYY x 10^{-6}	4.14	3.153	.202
3a Brake Application Speed + 5 Knots VI	160.4	217.4	228.2
3b Brake Application Speed + 10 Knots VI	168.9	225.9	236.7
3c Brake Application Speed + 20 Knots VI	185.8	242.8	253.6
3d Brake Application Speed + 30 Knots VI	202.7	259.7	270.5
3e Brake Application Speed - 5 Knots VI	143.6	200.6	211.4
3f Brake Application Speed - 10 Knots VI	135.2	192.1	202.9

[1] Equivalent value calculated using Appendix B, Volume I

Table 28.—Parametric Study Data (Concluded)

Test Condition and Parameter Changed	Airplane Model		
	B-52	KC-135	F-111
Airplane Parameters			
4a No Spoilers			
CL	1.0	.360	1.05
CD	.257	.131	.144
4b 80% Effective Spoilers			
CL	.444	.420	.434
CD	.3082	.1878	.2184
4c 60% Effective Spoilers			
CL	.583	.530	.588
CD	.2954	.1736	.1998
4d 40% Effective Spoilers			
CL	.722	.640	.742
CD	.2826	.1594	.1812
4e 20% Effective Spoilers			
CL	.861	.750	.896
CD	.2698	.1452	.1626
4f 120% Engine Idle Thrust			
FEO	5760	2880	1085
KE	-8.52	-4.26	-1.006
4g 110% Engine Idle Thrust			
FEO	5280	2640	994
KE	-9.59	-4.793	-1.132
4h 90% Engine Idle Thrust			
FEO	4320	2160	814
KE	-11.72	-5.858	-1.384
4i 80% Engine Idle Thrust			
FEO	3840	1920	723
KE	-12.78	-6.39	-1.51
2a Hot Day			
RHO	.00189	.00189	.00189
2b Cold Day			
RHO	.00309	.00309	.00309

Table 29.—Simulator Braking Distance Results (Distance in Feet)

CONDITION	B-52				KC-135				F-111			
AVAILABLE MU	0.6	0.4	0.2	0.1	0.6	0.4	0.2	0.1	0.6	0.4	0.2	0.1
BASELINE	1779*	*1775	3904	5694	1552	2283	5108	10885	2111	3300	7966	10054
80% SP	1786	1772	3940	5676	1628	2411	5453	11114	2251	3458	8329	10807
60% SP	1780	1798	4025	5806	1735	2579	6130	11916	2352	3707	8763	11296
40% SP	1818	1838	4146	6036	1829	2767	6542	11853	2543	4050	9752	12020
20% SP	1835	1907	4284	6204	1976	3000	6833	13552	2771	4384	10411	12868
NO SP	1853	2164	4400	6640	2143	3530	7520	14484	3060	4919	11334	13817
MAX WT	2822*	2798*	2784*	6784	4095*	4110*	6329	12939	2874*	3737*	8092	11331
HIGH WT	2278*	2288*	2989*	6136	2476*	2746	5787	11669	2252*	3543	8501	10870
LOW WT	1517*	1519*	3564	5150	1310	1925	4561	9527	1980	3137	7305	8910
MIN WT	1246*	1473*	3216	4613	1182	1789	4386	-	1928	3076	7084	8129
V_B + 5 Kn	1916	1934	4030	5875	1669	2436	5318	11139	2254	3548	8397	-
V_B + 10	2116	2109	4254	6105	1790	2589	5719	11515	2396	3769	8776	10526
V_B + 20	2418	2470	4508	6390	2024	2920	6346	12203	2667	4170	9449	11299
V_B + 30	2755	2866	4855	6850	2321	3282	6749	13037	2990	4616	9874	11990
V_B - 5	1633	1625	3466	5112	1441	2127	4759	10314	1991	3095	7575	9611
V_B - 10	1457	1460	3300	4967	1332	1987	4518	9909	1845	2929	7315	9139
120% Fe	1795	1784	4059	6143	1568	2302	5174	12221	2184	3343	8286	10856
110% Fe	1770	1771	3900	5751	1570	2314	5512	11545	2138	3246	8044	10644
90% Fe	1724	1723	3715	5280	1574	2285	5249	10625	2100	3204	7672	9922
80% Fe	1715	1726	3580	5082	1543	2246	4880	10303	2069	3149	7058	9301
Hot Day	1857	1857	4279	6281	1538	2329	5314	12397	[illegible]	3376	8317	11031
Cold Day	1628	1650	3413	4835	1537	2208	4662	9472	2060	3149	7137	8806

* Torque Limited Braking

Table 30.—B-52 Pi Determination

CONDITION	V	π_2 = .60		π_2 = .55		π_2 = .50		π_2 = .45		π_2 = .40		π_2 = .35	
		S	Sg/V^2	S	Sg/V^2	S	Sg/V^2	S	Sg/V^2	S	Sg/V^2	S	Sg/V^2
	FPS	[illegible]	π_1	FT	π_1	FT	π_1	FT	π_1	FT	π_1	FT	π_1
Baseline	152	1779	2.477	1766	2.459	1754	2.442	1762	2.454	1775	2.472	1748	2.434
		π_2 = .30		π_2 = .28		π_2 = .27		π_2 = .26		π_2 = .25		π_2 = .23	
		S	Sg/V^2	S	Sg/V^2	S	Sg/V^2	S	Sg/V^2	S	Sg/V^2	S	Sg/V^2
		FT	π_1	FT	π_1	FT	π_1	FT	π_1	FT	π_1	FT	π_1
		1852	2.579	2200	3.063	2354	3.278	2641	3.678	2826	3.939	3434	4.782
		π_2 = .225		π_2 = .22		π_2 = .20		π_2 = .175		π_2 = .150		π_2 = .125	
		S	Sg/V^2	S	Sg/V^2	S	Sg/V^2	S	Sg/V^2	S	Sg/V^2	S	Sg/V^2
		FT	π_1	FT	π_1	FT	π_1	FT	π_1	FT	π_1	FT	π_1
		3637	5.064	3733	5.198	3904	5.436	4245	5.911	4434	6.174	4872	6.784
		π_2 = .10		π_2 = .09		π_2 = .08		π_2 = .07		π_2 = .06		π_2 = .05	
		S	Sg/V^2	S	Sg/V^2	S	Sg/V^2	S	Sg/V^2	S	Sg/V^2	S	Sg/V^2
		FT	π_1	FT	π_1	FT	π_1	FT	π_1	FT	π_1	FT	π_1
		5694	7.929	5992	8.344	6305	8.780	6786	9.449	7203	10.03	7830	10.903

B Table 30.—B-52 Pi Determination (Continued)

CONDITION	V	C_L	C_D	C_L/C_D	π_2 = .6		π_2 = .4		π_2 = .2		π_2 = .1	
					S	Sg/V^2	S	Sg/V^2	S	Sg/V^2	S	Sg/V^2
	FPS	--	--	π_3	FT	π_1	FT	π_1	FT	π_1	FT	π_1
Baseline	152	.305	.321	0.950	1779	2.477	1775	2.472	3904	5.436	5694	7.929
80% Spoilers	152	.444	.308	1.441	1786	2.487	1772	2.467	3940	5.486	5676	7.904
60% Spoilers	152	.583	.295	1.974	1805	2.513	1798	2.504	4.025	5.605	5806	8.085
40% Spoilers	152	.722	.283	2.555	1818	2.532	1838	2.559	4146	5.773	5036	8.404
20% Spoilers	152	.861	.270	3.191	1836	2.555	1907	2.655	4284	5.965	6204	8.639
No Spoilers	152	1.00	.257	3.891	1853	2.580	2164	3.013	4400	6.127	6640	9.246

Table 30.—B-52 Pi Determination (Concluded)

CONDITION	V	Feo	Fe	$\frac{\rho V6}{Feg^2}$	π_2 = .6		π_2 = .4		π_2 = .2		π_2 = .1	
					S	Sg/V^2	S	Sg/V^2	S	Sg/V^2	S	Sg/V^2
	FPS	Lb_f	Lb_f	π_4	FT	π_1	FT	π_1	FT	π_1	FT	π_1
BASELINE	152	4800	3863	7341	1779	2.477	1775	2.472	3904	5.436	5694	7.929
MAX WT	[1]	4800	3586	46217	2822	2.182	2798	2.239	2784	3.880	6784	5.684
HIGH WT	[1]	4800	3724	19638	2278	2.313	2288	2.368	2989	4.166	6136	6.520
LOW WT	[1]	4800	3940	3926	1517	2.585	1519	2.551	3564	5.917	5150	8.502
MIN WT	[1]	4800	4018	1962	1246	2.652	1473	2.053	3216	6.476	4613	9.172
V_B + 5	160.4	4800	3818	10257	1916	2.396	1934	2.418	4030	5.039	5875	7.346
V_B + 10	168.9	4800	3773	14149	2116	2.386	2109	2.378	4254	4.798	6105	6.885
V_B + 20	185.8	4800	3683	25687	2418	2.253	2470	2.302	4508	4.201	6390	5.955
V_B + 30	202.7	4800	3693	44392	2755	2.157	2866	2.244	4855	3.802	6850	5.364
V_B - 5	143.6	4800	3908	5160	1633	2.548	1625	2.535	3466	5.408	5112	7.976
V_B - 10	135.2	4800	3952	3553	1457	2.564	1460	2.570	3300	5.808	4967	8.742
120% Fe	152	5760	5010	5660	1795	2.500	1784	2.484	4059	5.652	6142	8.554
110% Fe	152	5280	4436	6393	1770	2.465	1771	2.466	3900	5.431	5751	8.008
90% Fe	152	4320	3289	8623	1724	2.401	1723	2.399	3715	5.173	5280	7.325
80% Fe	152	3840	2715	10444	1715	2.388	1726	2.403	3580	4.985	5082	7.077
HOT DAY	152	4800	3863	5830	1857	2.586	1857	2.586	4279	5.958	6281	8.746
COLD DAY	152	4800	3863	9532	1628	2.267	1650	2.298	3413	4.753	4835	6.733

[1] Calculate using Appendix B, Volume I.

Table 31.—KC-135 Pi Determination

CONDITION	V	$\pi_2 = .60$		$\pi_2 = .55$		$\pi_2 = .50$		$\pi_2 = .45$		$\pi_2 = .40$		$\pi_2 = .35$	
		S	Sg/V^2	S	Sg/V^2	S	Sg/V^2	S	Sg/V^2	S	Sg/V^2	S	Sg/V^2
	FPS	FT	π_1	FT	π_1	FT	π_1	FT	π_1	FT	π_1	FT	π_1
Baseline	209	1552	1.143	1703	1.254	1893	1.394	2064	1.520	2283	1.681	2569	1.892
		$\pi_2 = .325$		$\pi_2 = .30$		$\pi_2 = .275$		$\pi_2 = .25$		$\pi_2 = .20$		$\pi_2 = .15$	
		S	Sg/V^2	S	Sg/V^2	S	Sg/V^2	S	Sg/V^2	S	Sg/V^2	S	Sg/V^2
		FT	π_1	FT	π_1	FT	π_1	FT	π_1	FT	π_1	FT	π_1
		2788	2.053	3040	2.239	3431	2.527	3884	2.861	5108	3.762	7082	5.216
		$\pi_2 = .125$		$\pi_2 = .10$		$\pi_2 = .166$		$\pi_2 = .154$		$\pi_2 = .137$			
		S	Sg/V^2	S	Sg/V^2	S	Sg/V^2	S	Sg/V^2	S	Sg/V^2	S	Sg/V^2
		FT	π_1	FT	π_1	FT	π_1	FT	π_1	FT	π_1	FT	π_1
		8604	6.337	10885	8.017	6205	4.570	6788	5.000	7756	5.712		

Table 31.—KC-135 Pi Determination (Continued)

CONDITION	V	C_L	C_D	CL/CD	π_2 = .6		π_2 = .4		π_2 = .2		π_2 = .1	
					S	Sg/V^2	S	Sg/V^2	S	Sg/V^2	S	Sg/V^2
	FPS	--	--	π_3	FT	π_1	FT	π_1	FT	π_1	FT	π_1
BASELINE	209	0.310	0.202	1.535	1552	1.143	2283	1.681	5108	3.762	10885	8.017
80% Spoilers	209	0.420	0.188	2.236	1628	1.199	2411	1.776	5453	4.016	11114	8.186
60% Spoilers	209	0.530	0.174	3.053	1735	1.278	2579	1.899	6130	4.515	11916	8.776
40% Spoilers	209	0.640	0.159	4.015	1829	1.347	2767	2.038	6542	4.818	11853	8.730
20% Spoilers	209	0.750	0.145	5.165	1976	1.455	3000	2.210	6333	5.033	13552	9.981
No Spoilers	209	0.860	0.131	6.565	2149	1.583	3530	2.600	7520	5.539	14484	10.688

Table 31.—KC-135 Pi Determination (Concluded)

CONDITION	V	Feo	Fe	$\frac{\rho V6}{Feg^2}$	π_2 = .6		π_2 = .4		π_2 = .2		π_2 = .1	
					S	Sg/V^2	S	Sg/V^2	S	Sg/V^2	S	Sg/V^2
	FPS	Lb_f	Lb_f	π_4	FT	π_1	FT	π_1	FT	π_1	FT	π_1
Baseline	209.0	2400	1780	107688	1552	1.143	2283	1.681	5108	3.762	10885	8.017
Max. Wt.	267.3	2400	1624	516319	4095	3.016	4110	3.026	6329	2.850	12939	5.826
High Wt.	240.8	2400	1695	254483	2476	1.823	2746	1.524	5787	3.211	11669	6.474
Low Wt.	183.3	2400	1878	47193	1310	1.254	1925	1.843	4561	4.367	9527	9.122
Min Wt.	171.7	2400	1879	31357	1182	1.290	1789	1.952	4386	4.786	---	---
V_B + 5	217.4	2400	1757	138146	1669	1.136	2436	1.658	5318	3.620	11139	7.582
V_B + 10	225.9	2400	1735	176161	1790	1.128	2589	1.632	5719	3.606	11515	7.260
V_B + 20	242.8	2400	1690	278816	2024	1.105	2920	1.594	6346	3.463	12203	6.660
V_B + 30	259.7	2400	1645	428923	2321	1.107	3282	1.566	6749	3.219	13037	6.219
V_B - 5	200.6	2400	1802	83[illegible]48[illegible]	1441	1.152	2127	1.701	4759	3.805	10314	8.246
V_B - 10	192.1	2400	1825	63330	1332	1.161	1987	1.732	4518	3.939	9909	8.639
120% Fe	209.0	2880	2384	80398	1568	1.155	2302	1.695	5174	3.811	12221	9.001
110% Fe	209.0	2640	2082	92066	1570	1.156	2313	1.704	5512	4.060	11545	8.503
90% Fe	209.0	2160	1478	129706	1575	1.160	2285	1.683	5249	3.866	10625	7.826
80% Fe	209.0	1920	1176	163024	1543	1.136	2246	1.654	4880	3.594	10303	7.588
Hot Day	209.0	2400	1780	85517	1538	1.133	2329	1.715	5314	3.914	12397	9.131
Cold Day	209.0	2400	1780	139813	1537	1.132	2208	1.626	4662	3.434	9472	6.976

Table 32.—F-111 Pi Determination

CONDITION	V	π_2 = .60		π_2 = .55		π_2 = .50		π_2 = .45		π_2 = .40		π_2 = .35	
		S	Sg/V^2	S	Sg/V^2	S	Sg/V^2	S	Sg/V^2	S	Sg/V^2	S	Sg/V^2
	FPS	FT	π_1	FT	π_1	FT	π_1	FT	π_1	FT	π_1	FT	π_1
Baseline	219.8	2111	1.406	2304	1.534	2556	1.702	2861	1.905	3300	2.198	3909	2.603
		π_2 = .30		π_2 = .275		π_2 = .260		π_2 = .250		π_2 = .240		π_2 = .230	
		S	Sg/V^2	S	Sg/V^2	S	Sg/V^2	S	Sg/V^2	S	Sg/V^2	S	Sg/V^2
		FT	π_1	FT	π_1	FT	π_1	FT	π_1	FT	π_1	FT	π_1
		4857	3.234	5399	3.595	5780	3.849	6315	4.205	6363	4.237	6693	4.457
		π_2 = .220		π_2 = .210		π_2 = .200		π_2 = .190		π_2 = .175		π_2 = .150	
		S	Sg/V^2	S	Sg/V^2	S	Sg/V^2	S	Sg/V^2	S	Sg/V^2	S	Sg/V^2
		FT	π_1	FT	π_1	FT	π_1	FT	π_1	FT	π_1	FT	π_1
		7027	4.679	7342	4.889	7966	5.305	8116	5.405	8751	5.827	10054	6.695

Table 32.—F-111 Pi Determination (Continued)

CONDITION	V	C_L	C_D	C_L/C_D	π_2 = .6		π_2 = .4		π_2 = .2		π_2 = .15	
					S	Sg/V^2	S	Sg/V^2	S	Sg/V^2	S	Sg/V^2
	FPS	--	--	π_3	FT	π_1	FT	π_1	FT	π_1	FT	π_1
Baseline	219.8	.280	.237	1.181	2111	1.406	3300	2.198	7966	5.305	10054	6.695
80% Spoilers	219.8	.434	.218	1.987	2251	1.499	3458	2.303	8329	5.546	10807	7.197
60% Spoilers	219.8	.588	.200	2.943	2352	1.566	3707	2.469	8763	5.835	11296	7.522
40% Spoilers	219.8	.742	.181	4.095	2543	1.693	4050	2.697	9752	6.494	12020	8.004
20% Spoilers	219.8	.896	.163	5.510	2771	1.845	4384	2.919	10411	6.933	12868	8.569
No Spoilers	219.8	1.050	.144	7.292	3060	2.038	4919	3.276	11334	7.548	13817	9.201

Table 32.–F-111 Pi Determination (Concluded)

CONDITION	V	Feo	Fe	$\frac{\rho V6}{Feg^2}$	π_2 = .6		π_2 = .4		π_2 = .2		π_2 = .15	
					S	Sg/V^2	S	Sg/V^2	S	Sg/V^2	S	Sg/V^2
	FPS	Lb_f	Lb_f	π_4	FT	π_1	FT	π_1	FT	π_1	FT	π_1
Baseline	219.8	904	751	345422	2111	1.406	3300	2.198	7966	5.305	10054	6.695
Max. Wt.	1▷	904	---	2▷	2874 TL	1.914 TL	3737 TL	2.489 TL	8092	4.623	11331	6.474
High Wt.	1▷	904	---	2▷	2252 TL	1.500 TL	3543	2.118	8051	5.116	10780	6.851
Low Wt.	1▷	904	756	2▷	1980	1.417	3137	2.246	7305	5.935	8910	7.239
Min Wt.	1▷	904	758	2▷	1928	1.434	3076	2.287	7084	5.994	8129	8.540
V_B + 5	228.2	904	745	435657	2254	1.393	3548	2.192	8397	5.188	Not Run	---
V_B + 10	236.7	904	740	546471	2396	1.376	3769	2.164	8776	5.039	10526	6.044
V_B + 20	253.6	904	729	838604	2667	1.334	4170	2.086	9449	4.727	11299	5.652
V_B + 30	270.5	904	719	1250662	2990	1.315	4616	2.030	9874	4.341	11990	5.272
V_B - 5	211.4	904	756	271498	1991	1.433	3095	2.228	7575	5.453	9611	6.919
V_B - 10	202.9	904	761	210751	1845	1.442	2929	2.289	7315	5.716	9139	7.142
120% Fe	219.8	1085	962	269430	2184	1.454	3343	2.226	8286	5.518	10856	7.229
110% Fe	219.8	994	856	302907	2138	1.424	3246	2.162	8044	5.357	10644	7.088
90% Fe	219.8	814	645	401820	2100	1.398	3204	2.134	7672	5.109	9922	6.607
80% Fe	219.8	723	539	481120	2069	1.378	3149	2.097	7058	4.700	9301	6.194
Hot Day	219.8	904	751	274305	2165	1.442	3376	2.248	8317	5.538	11031	7.346
Cold Day	219.3	904	751	448468	2060	1.372	3149	2.097	7187	4.786	8806	5.864

1▷ Calculated using procedure of Appendix B, Volume I

2▷ Calculated using 1▷ value.

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SECTION XIII
ARRANGEMENT OF PI TERMS

The experimental data converted to nondimensional pi terms must be arranged so that all of the pi terms containing independent variables, except one, remain constant. The remaining term is then varied to establish a relationship between it and π_1, the term containing the dependent variable. This procedure is repeated for each of the independently variable pi terms in the function. Tables 33 through 35 show the arrangement for each of the three airplanes. Each group of two pages is a complete data set with four sets per table, to show the data at 0.6μ, 0.4μ, 0.2μ, and 0.1μ (0.15μ for F-111) conditions.

Table 33.—B-52 Pi Arrangement

INDEPENDENT π TERM	DEPENDENT π TERM	π TERMS HELD CONSTANT		CONDITION
(π_2)	(π_1)	($\bar{\pi}_3$)	($\bar{\pi}_4$)	
.60	2.477	0.94	7341	BASELINE
.55	2.459			
.50	2.442			
.45	2.454			
.40	2.472			
.35	2.434			
.30	2.579			
.25	---			
.20	---			
.15	---			
.10	---			
.05	---			

(π_3)	(π_1)	($\bar{\pi}_2$)	($\bar{\pi}_4$)	CONDITION
0.950	2.477	0.60	7341	BASELINE
1.441	2.487			80% SPOILERS
1.974	2.513			60% SPOILERS
2.555	2.532			40% SPOILERS
3.191	2.555			20% SPOILERS
3.981	2.580			NO SPOILERS

Table 33.—B-52 Pi Arrangement (Continued)

INDEPENDENT π TERM	DEPENDENT π TERM	π TERMS HELD CONSTANT		
(π_4)	(π_1)	$\bar{\pi}_2$	$\bar{\pi}_3$	CONDITION
7341	2.477	0.60	0.94	BASELINE
46217	2.182			MAX WT
19638	2.313			HIGH WT
3926	2.585			LOW WT
1962	2.658			MIN WT
10257	2.396			V_B + 5
14149	2.386			V_B + 10
25687	2.253			V_B + 20
44392	2.157			V_B + 30
5160	2.548			V_B -5
3553	2.564			V_B -10
5660	2.500			120% Fe
6393	2.465			110% Fe
8623	2.401			90% Fe
10444	2.388			80% Fe
5830	2.585			HOT DAY
9532	2.267			COLD DAY

Table 33.—B-52 Pi Arrangement (Continued)

INDEPENDENT π TERM	DEPENDENT π TERM	π TERMS HELD CONSTANT		CONDITION
(π_2)	(π_1)	$(\bar{\pi}_3)$	$(\bar{\pi}_4)$	
.60	2.477	0.95	7341	BASELINE
.55	2.459			
.50	2.442			
.45	2.454			
.40	2.472			
.35	2.434			
.30	2.579			
–	–			
–	–			
–	–			
–	–			
–	–			

(π_3)	(π_1)	$(\bar{\pi}_2)$	$(\bar{\pi}_4)$	CONDITION
0.950	2.472	0.40	7341	BASELINE
1.441	2.467			80% SPOILERS
1.974	2.504			60% SPOILERS
2.555	2.559			40% SPOILERS
3.191	2.655			20% SPOILERS
3.891	3.013			NO SPOILERS

Table 33.—B-52 Pi Arrangement (Continued)

INDEPENDENT π TERM	DEPENDENT π TERM	π TERMS HELD CONSTANT		
(π_4)	(π_1)	$\bar{\pi}_2$	$\bar{\pi}_3$	CONDITION
7341	2.472	0.40	0.95	BASELINE
46217	2.239			MAX WT
19638	2.368			HIGH WT
3926	2.551			LOW WT
1962	2.053			MIN WT
10257	2.718			V_B + 5
14149	2.378			V_B + 10
25687	2.302			V_B + 20
44392	2.244			V_B + 30
5160	2.535			V_B -5
3553	2.570			V_B -10
5660	2.484			120% Fe
6393	2.466			110% Fe
8623	2.399			90% Fe
10444	2.403			80% Fe
5830	2.586			HOT DAY
9532	2.298			COLD DAY

Table 33.—B-52 Pi Arrangement (Continued)

INDEPENDENT π TERM	DEPENDENT π TERM	π TERMS HELD CONSTANT		CONDITION
(π_2)	(π_1)	$(\bar{\pi}_3)$	$(\bar{\pi}_4)$	
—	---	0.95	7341	BASELINE
.225	5.064			
.200	5.436			
.175	5.911			
.150	6.174			
.125	6.784			
.10	7.929			
.09	8.344			
.08	8.780			
.07	9.449			
.06	10.030			
.05	10.[illegible]03			

(π_3)	(π_1)	$(\bar{\pi}_2)$	$(\bar{\pi}_4)$	CONDITION
0.950	5.436	0.20	7341	BASELINE
1.441	5.486			80% SPOILERS
1.974	5.605			60% SPOILERS
2.555	5.773			40% SPOILERS
3.191	5.965			20% SPOILERS
3.891	6.127			NO SPOILERS

Table 33.—B-52 Pi Arrangement (Continued)

INDEPENDENT π TERM	DEPENDENT π TERM	π TERMS HELD CONSTANT		
(π_4)	(π_1)	$\bar{\pi}_2$	$\bar{\pi}_3$	CONDITION
7341	5.436	0.20	0.95	BASELINE
46217	3.880			MAX WT
19638	4.166			HIGH WT
3926	5.917			LOW WT
1962	6.476			MIN WT
10257	5.039			V_B + 5
14149	4.798			V_B + 10
25687	4.201			V_B + 20
44392	3.802			V_B + 30
5160	5.408			V_B -5
3553	5.808			V_B -10
5660	5.652			120% Fe
6393	5.431			110% Fe
8623	5.173			90% Fe
10444	4.985			80% Fe
5830	5.958			HOT DAY
9532	4.753			COLD DAY

Table 33.—B-52 Pi Arrangement (Continued)

INDEPENDENT π TERM	DEPENDENT π TERM	π TERMS HELD CONSTANT		CONDITION
(π_2)	(π_1)	($\bar{\pi}_3$)	($\bar{\pi}_4$)	
---	---	0.95	7341	BASELINE
.225	5.064			
.200	5.436			
.175	5.911			
.150	6.174			
.125	6.784			
.10	7.929			
.09	8.344			
.08	8.480			
.07	9.449			
.06	10.030			
.05	10.903			

(π_3)	(π_1)	($\bar{\pi}_2$)	($\bar{\pi}_4$)	CONDITION
0.950	7.929	0.10	7341	BASELINE
1.441	7.904			80% SPOILERS
1.974	8.085			60% SPOILERS
2.555	8.405			40% SPOILERS
3.191	8.639			20% SPOILERS
3.891	9.246			NO SPOILERS

Table 33.—B-52 Pi Arrangement (Concluded)

INDEPENDENT π TERM	DEPENDENT π TERM	π TERMS HELD CONSTANT		
(π_4)	(π_1)	$\bar{\pi}_2$	$\bar{\pi}_3$	CONDITION
7341	7.929	0.10	0.95	BASELINE
46217	5.681			MAX WT
19638	6.520			HIGH WT
3926	8.502			LOW WT
1962	9.172			MIN WT
10257	7.346			V_B + 5
14149	6.885			V_B + 10
25687	5.955			V_B + 20
44392	5.364			V_B + 30
5160	7.976			V_B -5
3553	8.742			V_B -10
5660	8.554			120% Fe
6393	8.008			110% Fe
8623	7.352			90% Fe
10444	7.077			80% Fe
5830	8.746			HOT DAY
9532	6.733			COLD DAY

Table 34.—KC-135 Pi Arrangement

INDEPENDENT π TERM	DEPENDENT π TERM	π TERMS HELD CONSTANT		CONDITION
(π_2)	(π_1)	$(\bar{\pi}_3)$	$(\bar{\pi}_4)$	
.60	1.143	1.535	107688	BASELINE
.55	1.254			
.50	1.394			
.45	1.520			
.40	1.681			
.35	1.892			
.325	2.053			
.30	2.239			
.20	---			
.15	---			
.10	---			
.05	---			

(π_3)	(π_1)	$(\bar{\pi}_2)$	$(\bar{\pi}_4)$	CONDITION
1.535	1.143	.6	107688	BASELINE
2.236	1.193			80% SPOILERS
3.053	1.278			60% SPOILERS
4.015	1.347			40% SPOILERS
5.165	1.455			20% SPOILERS
6.565	1.583			NO SPOILERS

Table 34.—KC-135 Pi Arrangement (Continued)

INDEPENDENT π TERM	DEPENDENT π TERM	π TERMS HELD CONSTANT		
(π_4)	(π_1)	$\bar{\pi}_2$	$\bar{\pi}_3$	CONDITION
107688	1.143	.6	1.535	BASELINE
516319	3.016			MAX WT
264483	1.823			HIGH WT
47193	1.254			LOW WT
31357	1.290			MIN WT
138146	1.136			V_B + 5
176161	1.128			V_B + 10
278816	1.105			V_B + 20
428923	1.107			V_B + 30
83148	1.152			V_B -5
63330	1.161			V_B -10
80398	1.155			120% Fe
92066	1.156			110% Fe
129706	1.160			90% Fe
163024	1.136			80% Fe
85517	1.133			HOT DAY
139813	1.132			COLD DAY

Table 34.—KC-135 Pi Arrangement (Continued)

INDEPENDENT π TERM	DEPENDENT π TERM	π TERMS HELD CONSTANT		CONDITION
(π_2)	(π_1)	$(\bar{\pi}_3)$	$(\bar{\pi}_4)$	
.60	1.143	1.535	107688	BASELINE
.55	1.254			
.50	1.394			
.45	1.520			
.40	1.681			
.35	1.892			
.325	2.053			
.30	2.239			
.20	---			
.15	---			
.10	---			
.05	---			

(π_3)	(π_1)	$(\bar{\pi}_2)$	$(\bar{\pi}_4)$	CONDITION
1.535	1.681	0.4	107688	BASELINE
2.236	1.776			80% SPOILERS
3.053	1.899			60% SPOILERS
4.015	2.038			40% SPOILERS
5.165	2.210			20% SPOILERS
6.565	2.600			NO SPOILERS

Table 34.—KC-135 Pi Arrangement (Continued)

INDEPENDENT π TERM	DEPENDENT π TERM	π TERMS HELD CONSTANT		
(π_4)	(π_1)	$\bar{\pi}_2$	$\bar{\pi}_3$	CONDITION
107688	1.681	0.4	1.535	BASELINE
516319	3.026			MAX WT
264483	1.524			HIGH WT
47193	1.843			LOW WT
31357	1.952			MIN WT
138146	1.658			V_B + 5
176161	1.632			V_B + 10
278816	1.594			V_B + 20
428923	1.566			V_B + 30
83148	1.701			V_B -5
63330	1.732			V_B -10
80398	1.695			120% Fe
92066	1.704			110% Fe
129706	1.683			90% Fe
163024	1.654			80% Fe
85517	1.715			HOT DAY
139813	1.626			COLD DAY

Table 34.—KC-135 Pi Arrangement (Continued)

INDEPENDENT π TERM	DEPENDENT π TERM	π TERMS HELD CONSTANT		CONDITION
(π_2)	(π_1)	($\bar{\pi}_3$)	($\bar{\pi}_4$)	
.60	---	1.535	107688	BASELINE
.55	---			
.50	---			
.45	---			
.40	---			
.35	---			
.275	2.527			
.25	2.861			
.20	3.762			
.15	5.216			
.125	6.337			
.10	8.017			

(π_3)	(π_1)	($\bar{\pi}_2$)	($\bar{\pi}_4$)	CONDITION
1.535	3.762	0.2	107688	BASELINE
2.236	4.016			80% SPOILERS
3.053	4.515			60% SPOILERS
4,015	4,818			40% SPOILERS
5.165	5.033			20% SPOILERS
6.565	5.539			NO SPOILERS

Table 34.—KC-135 Pi Arrangement (Continued)

INDEPENDENT π TERM	DEPENDENT π TERM	π TERMS HELD CONSTANT		
(π_4)	(π_1)	$\bar{\pi}_2$	$\bar{\pi}_3$	CONDITION
107688	3.762	0.2	1.535	BASELINE
516319	2.850			MAX WT
264483	3.211			HIGH WT
47193	4.367			LOW WT
31357	4.786			MIN WT
138146	3.620			V_B + 5
176161	3.606			V_B + 10
278816	3.463			V_B + 20
428923	3.219			V_B + 30
83148	3.805			V_B -5
63330	3.939			V_B -10
80398	3.811			120% Fe
92066	4.060			110% Fe
129706	3.866			90% Fe
163024	3.594			80% Fe
85517	3.914			HOT DAY
139813	3.434			COLD DAY

Table 34.—KC-135 Pi Arrangement (Continued)

INDEPENDENT π TERM	DEPENDENT π TERM	π TERMS HELD CONSTANT		CONDITION
(π_2)	(π_1)	($\bar{\pi}_3$)	($\bar{\pi}_4$)	
.60	---	1.535	107688	BASELINE
.55	---			
.50	---			
.45	---			
.40	---			
.35	---			
.275	2.527			
.25	2.861			
.20	3.762			
.15	5.216			
.125	6.337			
.10	8.017			

(π_3)	(π_1)	($\bar{\pi}_2$)	($\bar{\pi}_4$)	CONDITION
1.535	8.017	0.1	107688	BASELINE
2.236	8.186			80% SPOILERS
3.053	8.776			60% SPOILERS
4.015	8.730			40% SPOILERS
6.165	9.981			20% SPOILERS
6.565	10.668			NO SPOILERS

Table 34.—KC-135 Pi Arrangement (Concluded)

INDEPENDENT π TERM (π_4)	DEPENDENT π TERM (π_1)	π TERMS HELD CONSTANT $\bar{\pi}_2$	$\bar{\pi}_3$	CONDITION
107688	8.017	0.1	1.535	BASELINE
516319	5.826			MAX WT
264483	6.474			HIGH WT
47193	9.122			LOW WT
31357	---			MIN WT
138146	7.582			V_B + 5
176161	7.260			V_B + 10
278816	6.660			V_B + 20
428923	6.219			V_B + 30
83148	8.246			V_B -5
63330	8.639			V_B -10
80398	9.001			120% Fe
92066	8.503			110% Fe
129706	7.826			90% Fe
163024	7.588			80% Fe
85517	9.131			HOT DAY
139813	6.976			COLD DAY

Table 35.—F-111 Pi Arrangement

INDEPENDENT π TERM	DEPENDENT π TERM	π TERMS HELD CONSTANT		CONDITION
(π_2)	(π_1)	$(\bar{\pi}_3)$	$(\bar{\pi}_4)$	
.60	1.406	1.181	345422	BASELINE
.55	1.534			
.50	1.702			
.45	1.905			
.40	2.198			
.35	2.603			
.30	---			
.25	---			
.20	---			
.15	---			
.10	---			
.05	---			

(π_3)	(π_1)	$(\bar{\pi}_2)$	$(\bar{\pi}_4)$	CONDITION
1.181	1.406	0.6	345422	BASELINE
1.987	1.499			80% SPOILERS
2.943	1.566			60% SPOILERS
4.095	1.693			40% SPOILERS
5.510	1.845			20% SPOILERS
7.292	2.038			NO SPOILERS

Table 35.—F-111 Pi Arrangement (Continued)

INDEPENDENT π TERM	DEPENDENT π TERM	π TERMS HELD CONSTANT		
(π_4)	(π_1)	$\bar{\pi}_2$	$\bar{\pi}_3$	CONDITION
345422	1.406	0.6	1.181	BASELINE
–	1.914 TL			MAX WT
–	1.500 TL			HIGH WT
276293	1.417			LOW WT
245635	1.434			MIN WT
435657	1.393			$V_B + 5$
546471	1.376			$V_B + 10$
838604	1.334			$V_B + 20$
1250622	1.315			$V_B + 30$
271496	1.433			$V_B -5$
210751	1.442			$V_B -10$
269430	1.454			120% Fe
302907	1.424			110% Fe
401820	1.398			90% Fe
481120	1.378			80% Fe
274305	1.442			HOT DAY
448468	1.372			COLD DAY

TL = Torque Limited

Table 35.—F-111 Pi Arrangement (Continued)

INDEPENDENT π TERM	DEPENDENT π TERM	π TERMS HELD CONSTANT		CONDITION
(π_2)	(π_1)	($\bar{\pi}_3$)	($\bar{\pi}_4$)	
.60	1.406	1.181	345422	BASELINE
.55	1.534			
.50	1.702			
.45	1.905			
.40	2.198			
.35	2.603			
.30	---			
.25	---			
.20	---			
.15	---			
.10	---			
.05	---			

(π_3)	(π_1)	($\bar{\pi}_2$)	($\bar{\pi}_4$)	CONDITION
1.181	2.198	0.4	345422	BASELINE
1.987	2.303			80% SPOILERS
2.943	2.469			60% SPOILERS
4.095	2.697			40% SPOILERS
5.510	2.919			20% SPOILERS
7.292	3.276			NO SPOILERS

Table 35.—F-111 Pi Arrangement (Continued)

INDEPENDENT π TERM	DEPENDENT π TERM	π TERMS HELD CONSTANT		
(π_4)	(π_1)	$\bar{\pi}_2$	$\bar{\pi}_3$	CONDITION
345422	2.198	0.4	1.181	BASELINE
	2.489 TL			MAX WT
482585	2.118			HIGH WT
276293	2.246			LOW WT
245635	2.287			MIN WT
435657	2.192			V_B + 5
546471	2.164			V_B + 10
838604	2.086			V_B + 20
1250662	2.030			V_B + 30
271498	2.228			V_B -5
210751	2.289			V_B -10
269430	2.226			120% Fe
302907	2.162			110% Fe
401820	2.134			90% Fe
481120	2.097			80% Fe
274305	2.248			HOT DAY
448468	2.097			COLD DAY

TL = Torque Limited

Table 35.—F-111 Pi Arrangement (Continued)

INDEPENDENT π TERM	DEPENDENT π TERM	π TERMS HELD CONSTANT		CONDITION
(π_2)	(π_1)	($\bar{\pi}_3$)	($\bar{\pi}_4$)	
.300	3.234	1.181	345422	BASELINE
.275	3.595			
.260	3.849			
.250	4.205			
.240	4.237			
.230	4.457			
.220	4.679			
.210	4.889			
.200	5.305			
.190	5.405			
.175	5.827			
.150	6.695			

(π_3)	(π_1)	($\bar{\pi}_2$)	($\bar{\pi}_4$)	CONDITION
1.181	5.305	.2	345422	BASELINE
1.987	5.546			80% SPOILERS
2.943	5.835			60% SPOILERS
4.095	6.494			40% SPOILERS
5.510	6.933			20% SPOILERS
7.292	7.548			NO SPOILERS

Table 35.—F-111 Pi Arrangement (Continued)

INDEPENDENT π TERM	DEPENDENT π TERM	π TERMS HELD CONSTANT		
(π_4)	(π_1)	$\bar{\pi}_2$	$\bar{\pi}_3$	CONDITION
345422	5.305	.2	1.181	BASELINE
555118	4.623			MAX WT
399186	5.116			HIGH WT
186981	5.935			LOW WT
164990	5.994			MIN WT
435657	5.188			V_B + 5
546471	5.039			V_B + 10
838604	4.727			V_B + 20
1250662	4.341			V_B + 30
271498	5.453			V_B -5
210751	5.716			V_B -10
269430	5.518			120% Fe
302907	5.357			110% Fe
401820	5.109			90% Fe
481120	4.700			80% Fe
274305	5.538			HOT DAY
448468	4.786			COLD DAY

Table 35.—F-111 Pi Arrangement (Continued)

INDEPENDENT π TERM	DEPENDENT π TERM	π TERMS HELD CONSTANT		CONDITION
(π_2)	(π_1)	($\bar{\pi}_3$)	($\bar{\pi}_4$)	
.300	3.234	1.181	345422	BASELINE
.275	3.595			
.260	3.849			
.250	4.205			
.240	4.237			
.230	4.457			
.220	4.679			
.210	4.889			
.200	5.305			
.190	5.405			
.175	5.827			
.150	6.695			

(π_3)	(π_1)	($\bar{\pi}_2$)	($\bar{\pi}_4$)	CONDITION
1.181	6.695	.15	345422	BASELINE
1.987	7.197			80° SPOILERS
2.943	7.522			60° SPOILERS
4.095	8.004			40° SPOILERS
5.510	8.569			20° SPOILERS
7.292	9.201			[illegible]0 SPOILERS

Table 35.—F-111 Pi Arrangement (Concluded)

INDEPENDENT π TERM	DEPENDENT π TERM	π TERMS HELD CONSTANT		
(π_4)	(π_1)	$\bar{\pi}_2$	$\bar{\pi}_3$	CONDITION
345422	6.695	.15	1.181	BASELINE
555118	6.474			MAX WT
399186	6.851			HIGH WT
186981	7.239			LOW WT
164990	8.540			MIN WT
435657	---			V_B + 5
546471	6.044			V_B + 10
838604	5.652			V_B + 20
1250662	5.272			V_B + 30
271498	6.919			V_B -5
210751	7.142			V_B -10
269430	7.229			120% Fe
302907	7.088			110% Fe
401820	6.607			90% Fe
481120	6.194			80% Fe
274305	7.346			HOT DAY
448468	5.864			COLD DAY

SECTION XIV
FORMULATION OF MODEL PREDICTION EQUATIONS AND MODEL-TO-SIMULATOR CORRELATION CALCULATIONS

After the conditions have been met for the function to be a product, a prediction equation is formed by multiplying all component equations and the constant term C. That is:

$$(\pi_1) = C\, f_1\,(\pi_2, \overline{\pi}_3, \overline{\pi}_4)\, f_2\,(\overline{\pi}_2, \pi_3, \overline{\pi}_4)\, f_3\,(\overline{\pi}_2, \overline{\pi}_3, \pi_4)$$

Therefore, for the B-52 airplane at $\overline{\pi}_2 = 0.6$: –

$$(\pi_1) = 0.16561 \times 2.3931(\pi_2)^{-.04007} 2.4772(\pi_3)^{[.03021-.01786\%SP]}$$

$$4.4960(\pi_4)^{[9.05\Delta\rho-.06803]}$$

or:

$$\boxed{(\pi_1) = 4.4138(\pi_2)^{-0.04007}(\pi_3)^{[.03021-.01786\%SP]}(\pi_4)^{[9.05\Delta\rho-.06803]}} \qquad (1)$$

For the B-52 at $\overline{\pi}_2 = 0.4$: –

$$(\pi_1) = 0.16272 \times 2.3931(\pi_2)^{-.04007} 2.4815(\pi_3)^{[.1285-.2227\%SP]}\ 4.0297(\pi_4)^{[8.48\Delta\rho-.0554]}$$

or:

$$\boxed{(\pi_1) = 3.8935(\pi_2)^{-.04007}(\pi_3)^{[.1285-.2227\%SP]}(\pi_4)^{[8.48\Delta\rho-.0554]}} \qquad (2)$$

and so on.

This process was repeated for the other airplanes and corresponding prediction equations were obtained. The prediction equations were then used to calculate prediction stopping distance (π term) and compared with actual stopping distance (π term) for correlation. The difference between the two was converted to a percentage error based on the actual stopping distance (π term). Tables 36 through 38 illustrate this correlation comparison.

Table 36.—B-52 Model-To-Simulator Correlation

0.6μ

$$(\pi_1) = 4.4139(\pi_2)^{-.04007}(\pi_3)^{.03021-.01786\%SP}(\pi_4)^{9.05\Delta\rho-.06803}$$

DATA FOR $\bar{\pi}_2$ = 0.6			DATA FOR $\bar{\pi}_2$ = 0.4			μ = 0.6*
PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	CONDITION
2.457	2.477	.81	2.497	2.472	-1.04	BASELINE
2.473	2.487	.56	2.514	2.467	-1.87	80% SP
2.492	2.513	.87	2.532	2.564	-1.14	60% SP
2.513	2.532	.75	2.554	2.559	.22	40% SP
2.536	2.555	.75	2.577	2.655	2.94	20% SP
2.562	2.580	.72	2.604	3.013	13.6	NO SP
2.168	2.182	.62	2.220	2.239	.86	MAX WT
2.298	2.313	.65	2.345	2.368	.97	HIGH WT
2.564	2.585	.82	2.598	2.551	-1.83	LOW WT
2.688	2.658	-1.12	---	---	---	MIN WT
2.402	2.396	-.25	2.441	2.418	-.94	V_B + 5 Kn
2.350	2.386	1.53	2.388	2.378	-.42	V_B + 10
2.256	2.253	-.14	2.293	2.302	.37	V_B + 20
2.174	2.157	-.78	2.210	2.244	1.54	V_B + 30
2.517	2.548	1.21	2.558	2.535	-.90	V_B -5
2.582	2.564	-.67	2.624	2.570	-2.11	V_B -10
2.501	2.500	-.06	2.542	2.484	-2.33	120% Fe
2.480	2.465	-.64	2.521	2.466	-2.23	110% Fe
2.430	2.401	-1.24	2.470	2.399	-2.96	90% Fe
2.399	2.388	-.45	2.438	2.403	-1.45	80% Fe
2.557	2.586	1.10	2.599	2.586	-0.50	HOT DAY
2.244	2.267	1.00	2.280	2.298	0.78	COLD DAY

* Value of μ for data set used to arrive at the prediction equation shown.

Table 36.—B-52 Model-To-Simulator Correlation (Continued)

0.4μ

$$(\pi_1) = 3.8939(\pi_2)^{-.04007}(\pi_3)^{.1285-.2227\%SP}(\pi_4)^{8.48\Delta\rho-.0554}$$

DATA FOR $\bar{\pi}_2$ = 0.4			DATA FOR $\bar{\pi}_2$ = 0.6			μ = 0.4*
PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	CONDITION
2.479	2.472	-.29	2.439	2.477	.54	BASELINE
2.423	2.467	1.82	2.383	2.487	4.16	80% SP
2.458	2.504	1.81	2.419	2.513	3.77	60% SP
2.560	2.559	-.02	2.518	2.532	0.52	40% SP
2.719	2.655	-2.41	2.675	2.555	-4.70	20% SP
2.938	3.013	2.51	2.890	2.580	-12.0 *	NO SP
2.252	2.239	-.58	2.202	2.182	-.95	MAX WT
2.355	2.368	.55	2.309	2.313	.16	HIGH WT
2.560	2.551	-.34	2.525	2.585	2.34	LOW WT
---	---	---	2.624	2.658	1.30	MIN WT
2.433	2.418	-.62	2.394	2.396	.08	V_B + 5 Kn
2.390	2.378	-.50	2.352	2.386	1.46	V_B + 10
2.313	2.302	-.47	2.275	2.253	-.97	V_B + 20
2.244	2.244	.02	2.207	2.157	-2.32	V_B + 30
2.528	2.535	.29	2.487	2.548	2.39	V_B -5
2.581	2.570	-.42	2.539	2.564	1.00	V_B -10
2.515	2.484	-1.24	2.474	2.500	1.02	120% Fe
2.498	2.466	-1.29	2.457	2.465	.29	110% Fe
2.457	2.399	-2.40	2.417	2.401	-.68	90% Fe
2.431	2.403	-1.14	2.392	2.388	-.14	80% Fe
2.603	2.586	-0.64	2.560	2.586	1.00	HOT DAY
2.312	2.298	-0.60	2.275	2.267	0.35	COLD DAY

Table 36.—B-52 Model-To-Simulator Correlation (Continued)

0.23 μ

$$(\pi_1) = .90063(\pi_2)^{-2.2504}(\pi_3)^{.13006-.07741\%SP}(\pi_4)^{17.75\Delta\rho-.18364}$$

Wet Runway

DATA FOR $\bar{\pi}_2$ = 0.[illegible]			DATA FOR $\bar{\pi}_2$ = 0.23			μ = 0.23
PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	CONDITION
			4.785	4.782	-.07	BASELINE
			4.919	4.967	.97	80% SP
			5.079	5.062	-.33	60% SP
			5.265	5.286	.39	40% SP
			5.480	5.472	-.14	20% SP
			5.725	5.751	.45	NO SP
			3.530	3.468	-1.78	MAX WT
			4.071	3.996	-1.87	HIGH WT
			5.295	5.426	2.41	LOW WT
			5.862	5.995	2.22	MIN WT
			4.499	4.482	-.39	V_B + 5 Kn
			4.240	4.288	1.11	V_B + 10
			3.799	3.884	2.19	V_B + 20
			3.435	3.563	3.58	V_B + 30
			5.106	4.958	-2.98	V_B -5
			5.469	5.328	-2.66	V_B -10
			5.020	5.010	-.19	120% Fe
			4.909	4.842	-1.38	110% Fe
			4.645	4.673	.60	90% Fe
			4.484	4.559	1.64	80% Fe
			5.415	5.438	0.42	HOT DAY
			4.088	4.126	0.42	COLD DAY

Table 36.—B-52 Model-To-Simulator Correlation (Continued)

0.2 μ

$$(\pi_1) = 11.6779(\pi_2)^{-.5166}(\pi_3)^{.09091-.07014\%SP}(\pi_4)^{12.5\Delta\rho-.182052}$$

DATA FOR $\bar{\pi}_2$ = 0.2			DATA FOR $\bar{\pi}_2$ = 0.1			μ = 0.2
PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	CONDITION
5.299	5.436	2.52	7.581	7.929	4.38	BASELINE
5.373	5.486	2.07	7.686	7.904	2.75	80% SP
5.484	5.605	2.15	7.845	8.085	2.96	60% SP
5.627	5.773	2.53	8.050	8.405	4.22	40% SP
5.800	5.965	2.77	8.297	8.639	3.95	20% SP
6.002	6.127	2.03	8.587	9.246	7.13*	NO SP
---	---	---	5.678	5.681	0.06	MAX WT
---	---	---	6.504	6.520	0.25	HIGH WT
5.852	5.917	1.10	8.345	8.502	1.84	LOW WT
6.523	6.476	-0.73	9.266	9.172	-1.02	MIN WT
4.986	5.039	1.05	7.133	7.346	2.90	V_B + 5 Kn
4.703	4.798	1.98	6.728	6.885	2.29	V_B + 10
4.219	4.201	-0.42	6.035	5.955	-1.35	V_B + 20
3.819	3.802	-0.46	5.463	5.364	-1.86	V_B + 30
5.651	5.408	-4.50	8.084	7.976	-1.36	V_B -5
6.048	5.808	-4.12	8.652	8.742	1.03	V_B -10
5.556	5.652	1.69	7.949	8.554	7.08*	120% Fe
5.435	5.431	-0.07	7.775	8.008	2.92	110% Fe
5.146	5.173	0.52	7.362	7.352	-0.13	90% Fe
4.970	4.985	0.30	7.110	7.077	-0.47	80% Fe
5.829	5.958	2.16	8.339	8.746	4.65	HOT DAY
4.660	4.753	1.96	6.667	7.633	0.98	COLD DAY

Table 36.—B-52 Model-To-Simulator Correlation (Concluded)

$.1\mu$

$$(\pi_1) = 13.5275(\pi_2)^{-.5165}(\pi_3)^{.11144-.1367\%SP}(\pi_4)^{16.11\Delta\rho-.196156}$$

DATA FOR $\bar{\pi}_2$ = 0.1			DATA FOR $\bar{\pi}_2$ = 0.2			μ = 0.1*
PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	CONDITION
7.744	7.929	2.33	5.413	5.436	0.42	BASELINE
7.740	7.904	2.07	5.410	5.486	1.38	80% SP
7.891	8.085	2.40	5.516	5.605	1.59	60% SP
8.157	8.405	2.95	5.702	5.773	1.23	40% SP
8.527	8.639	1.29	5.961	5.965	0.08	20% SP
8.999	9.246	2.68	6.290	6.127	-2.66	NO SP
5.672	5.681	0.17	---	---	---	MAX WT
6.565	6.520	-0.69	---	---	---	HIGH WT
8.589	8.502	-1.02	6.024	6.917	-1.81	LOW WT
9.614	9.172	-4.81	6.772	6.476	-4.56	MIN WT
7.253	7.346	1.28	5.070	5.039	-0.60	V_B + 5 Kn
6.809	6.885	1.10	4.760	4.798	0.79	V_B + 10
6.057	5.955	-1.72	4.234	4.201	-0.78	V_B + 20
5.441	5.364	-1.44	3.803	3.802	-0.05	V_B + 30
8.299	7.976	-4.05	5.801	5.408	-7.28*	V_B -5
8.929	8.742	-2.13	6.241	5.808	-7.46*	V_B -10
8.150	8.554	4.73	5.697	5.652	-0.79	120% Fe
7.957	8.008	0.64	5.562	5.431	-2.42	110% Fe
7.504	7.352	-2.06	5.245	5.173	-1.39	90% Fe
7.227	7.077	-2.12	5.052	4.985	-1.34	80% Fe
8.699	8.746	0.53	6.081	5.958	2.06	HOT DAY
6.644	6.733	1.33	4.644	4.753	2.29	COLD DAY

Table 37.—KC-135 Model-To-Simulator Correlation

0.6..

$$(\pi_1) = 1.28745(\pi_2)^{-.9420}(\pi_3)^{.1903-.1090\%SP}(\pi_4)^{-.05414}$$

DATA FOR $\bar{\pi}_2$ = 0.6			DATA FOR $\bar{\pi}_2$ = 0.4			μ = 0.6*
PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	CONDITION
1.152	1.143	-.77	1.688	1.681	-.36	BASELINE
1.209	1.199	-.80	1.771	1.776	.27	80% SP
1.279	1.278	-.07	1.874	1.899	1.36	60% SP
1.364	1.347	-1.26	1.999	2.038	1.94	40% SP
1.467	1.455	-.79	2.149	2.210	2.73	20% SP
1.591	1.583	-.54	2.332	2.600	10.32*	NO SP
---	---	---	---	---	---	MAX WT
---	---	---	1.607	1.524	-5.51*	HIGH WT
1.204	1.254	3.98	1.765	1.843	4.26	LOW WT
1.231	1.290	4.53	1.804	1.952	7.59*	MIN WT
1.136	1.136	-.03	1.665	1.658	-.41	V_B + 5 Kn
1.122	1.128	.61	1.643	1.632	-.67	V_B + 10
1.094	1.105	.95	1.603	1.594	-.59	V_B + 20
1.069	1.107	3.46	1.566	1.566	-.02	V_B + 30
1.168	1.152	-1.39	1.711	1.701	-.64	V_B -5
1.185	1.161	-2.08	1.737	1.732	-.26	V_B -10
1.170	1.155	-1.33	1.715	1.695	-1.12	120% Fe
1.162	1.156	-.46	1.702	1.704	.09	110% Fe
1.140	1.160	1.70	1.671	1.683	.73	90% Fe
1.125	1.136	.90	1.650	1.654	.25	80% Fe
1.166	1.133	-2.96	1.709	1.715	.38	HOT DAY
1.136	1.132	-.32	1.664	1.626	-2.32	COLD DAY

Table 37.—KC-135 Model-To-Simulator Correlation (Continued)

0.4_μ

$$(\pi_1) = 1.80994\,(\pi_2)^{-.9420}\,(\pi_3)^{.2233-.2072\%SP}\,(\pi_4)^{-.08228}$$

$\bar{\pi}_2$ = 0.4			$\bar{\pi}_2$ = 0.6			$\mu = 0.4$
PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	CONDITION
1.693	1.681	-.67	1.155	1.143	-1.07	BASELINE
1.761	1.776	.84	1.202	1.199	-.23	80% SP
1.877	1.899	1.16	1.281	1.278	-.28	60% SP
2.043	2.038	-.27	1.395	1.347	-3.53	40% SP
2.266	2.210	-2.55	1.547	1.455	-6.27*	20% SP
2.559	2.600	1.68	1.747	1.583	-10.35*	NO SP
---	---	---	---	---	---	MAX WT
1.572	1.524	-3.19	---	---	---	HIGH WT
1.812	1.843	1.71	1.237	1.254	1.42	LOW WT
1.874	1.952	4.03	1.279	1.290	.86	MIN WT
1.658	1.658	-.01	1.132	1.136	.37	V_B + 5 Kn
1.626	1.632	.41	1.110	1.128	1.68	V_B + 10
1.565	1.594	1.77	1.068	1.105	3.28	V_B + 20
1.511	1.566	3.50	1.031	1.107	6.86*	V_B + 30
1.729	1.701	-1.68	1.180	1.162	-2.44	V_B -5
1.768	1.732	-2.08	1.207	1.161	-3.93	V_B -10
1.734	1.695	-2.27	1.183	1.155	-2.48	120% Fe
1.715	1.704	-.65	1.170	1.156	-1.21	110% Fe
1.667	1.683	.94	1.138	1.160	1.91	90% Fe
1.636	1.654	1.10	1.117	1.136	1.75	80% Fe
1.725	1.715	-.57	1.177	1.133	-3.95	HOT DAY
1.657	1.626	-1.88	1.131	1.132	.11	COLD DAY

Table 37.—KC-135 Model-To-Simulator Correlation (Continued)

0.2

$$(\pi_1) = 3.1969\,(\pi_2)^{-1.1410}\,(\pi_3)^{.2577-.0267\%SP}\,(\pi_4)^{3.5\Delta\rho\,-.152082}$$

$\bar{\pi}_2$ =			$\bar{\pi}_2$ = 0.2			
PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	CONDITION
			3.801	3.762	-1.04	BASELINE
			4.164	4.016	-3.69	80% SP
			4.509	4.515	.13	60% SP
			4.854	4.818	-.73	40% SP
			5.210	5.033	-3.53	20% SP
			5.591	5.539	-.95	NO SP
			2.995	2.850	-5.09	MAX WT
			3.316	3.211	-3.26	HIGH WT
			4.309	4.367	1.33	LOW WT
			4.586	4.786	4.19	MIN WT
			3.660	3.620	-1.10	V_B + 5 Kn
			3.527	3.606	2.18	V_B + 10
			3.289	3.463	5.03	V_B + 20
			3.081	3.219	4.31	V_B + 30
			3.954	3.805	-3.91	V_B -5
			4.121	3.939	-4.62	V_B -10
			3.974	3.811	-4.28	120% Fe
			3.893	4.060	4.11	110% Fe
			3.695	3.866	4.42	90% Fe
			3.569	3.594	.71	80% Fe
			4.013	3.914	2.53	HOT DAY
			3.546	3.434	3.26	COLD DAY

Table 37.—KC-135 Model-To-Simulator Correlation (Concluded)

0.1

$$(\pi_1) = 6.0204 \; (\pi_2)^{-1.1410} \; (\pi_3)^{.1485-.1643\%SP} \; (\pi_4)^{12.65\Delta\rho - .200863}$$

$\bar{\pi}_2 =$			$\bar{\pi}_2 = 0.1$			
PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	CONDITION
			8.071	8.017	-.67	BASELINE
			8.238	8.186	-.64	80% SP
			8.591	8.776	2.11	60% SP
			9.116	8.730	-4.43	40% SP
			9.825	9.981	1.57	20% SP
			10.745	10.668	-.72	NO SP
			5.891	5.826	-1.10	MAX WT
			6.738	6.474	-4.07	HIGH WT
			9.525	9.122	-4.42	LOW WT
			---	---	---	MIN WT
			7.677	7.582	-1.25	V_B + 5 Kn
			7.311	7.260	-.71	V_B + 10
			6.667	6.660	-.11	V_B + 20
			6.114	6.219	1.68	V_B + 30
			8.501	8.246	-3.09	V_B -5
			8.979	8.639	-3.94	V_B -10
			8.559	9.001	4.91	120% Fe
			8.329	8.503	2.05	110% Fe
			7.775	7.826	.65	90% Fe
			7.426	7.588	2.14	80% Fe
			9.069	9.131	0.68	HOT DAY
			6.885	6.976	1.32	COLD DAY

Table 38.—F-111 Model-To-Simulator Correlation

0.6

$$(\pi_1) = 1.6343\,(\pi_2)^{-1.1411}\,(\pi_3)^{.1890-.1286\%SP}\,(\pi_4)^{-.05843}$$

$\bar{\pi}_2$ =			$\bar{\pi}_2 = 0.6$			
PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	CONDITION
1.404	1.406	.15	2.229	2.198	-1.45	BASELINE
1.474	1.499	1.65	2.342	2.303	-1.69	80% SP
1.568	1.566	-.11	2.490	2.469	-.88	60% SP
1.687	1.693	.38	2.680	2.697	.65	40% SP
1.836	1.845	.49	2.916	2.919	.10	20% SP
2.023	2.038	.73	3.213	3.276	1.91	NO SP
---	---	---	---	---	---	MAX WT
---	---	---	2.186	2.118	-3.24	HIGH WT
1.422	1.417	-.34	2.259	2.246	-.59	LOW WT
1.432	1.434	.12	2.274	2.287	.57	MIN WT
1.385	1.393	.56	2.199	2.192	-.34	V_B + 5 Kn
1.367	1.376	.68	2.170	2.164	-.29	V_B + 10
1.333	1.334	.10	2.117	2.086	-1.48	V_B + 20
1.302	1.315	.97	2.068	2.030	-1.88	V_B + 30
1.424	1.433	.68	2.261	2.228	-1.48	V_B -5
1.445	1.442	-.20	2.295	2.289	-.25	V_B -10
1.424	1.454	2.07	2.262	2.226	-1.61	120% Fe
1.414	1.424	.65	2.247	2.162	-3.93	110% Fe
1.391	1.398	.51	2.210	2.134	-3.57	90% Fe
1.377	1.378	.08	2.187	2.097	-4.28	80% Fe
1.423	1.442	1.32	2.260	2.248	-.51	HOT DAY
1.382	1.372	-.77	2.196	2.097	-4.71	COLD DAY

Table 38.—F-111 Model-To-Simulator Correlation (Continued)

0.4

$$(\pi_1) = 1.8069\ (\pi_2)^{-1.1411}\ (\pi_3)^{.2060-.1448\%SP}\ (\pi_4)^{-.06742}$$

$\bar{\pi}_2$ =			$\bar{\pi}_2$ = 0.4			
PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	CONDITION
2.198	2.198	0.0	1.384	1.406	1.55	BASELINE
2.315	2.303	-.52	1.457	1.499	2.77	80% SP
2.474	2.469	-.23	1.558	1.566	.53	60% SP
2.681	2.697	.60	1.688	1.693	.33	40% SP
2.943	2.919	-.82	1.853	1.845	-.42	20% SP
3.276	3.276	0.0	2.063	2.038	-1.22	NO SP
---	---	---	---	---	---	MAX WT
2.149	2.118	-1.48	---	---	---	HIGH WT
2.232	2.246	.62	1.405	1.417	.87	LOW WT
2.249	2.287	1.66	1.416	1.434	1.22	MIN WT
2.164	2.192	1.27	1.362	1.393	2.16	V_B + 5 Kn
2.131	2.164	1.52	1.342	1.376	2.47	V_B + 10
2.071	2.086	.74	1.304	1.334	2.29	V_B + 20
2.015	2.030	.71	1.269	1.315	3.49	V_B + 30
2.234	2.228	-.27	1.407	1.433	1.86	V_B -5
2.273	2.289	.71	1.431	1.442	.76	V_B -10
2.235	2.226	-.41	1.407	1.454	3.23	120% Fe
2.218	2.162	-2.60	1.396	1.424	1.93	110% Fe
2.176	2.134	-1.98	1.370	1.398	2.04	90% Fe
2.150	2.097	-2.51	1.353	1.378	1.77	80% Fe
2.288	2.248	.69	1.406	1.442	2.50	HOT DAY
2.160	2.097	-3.00	1.360	1.372	.87	COLD DAY

Table 38.—F-111 Model-To-Simulator Correlation (Continued)

0.20						
$(\pi_1) = 7.7773\,(\pi_2)^{-1.0490}\,(\pi_3)^{.1885-.1184\%SP}\,(\pi_4)^{-.1648}$						
$\bar{\pi}_2$ =			$\bar{\pi}_2$ = .020			
PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	CONDITION
			5.205	5.305	1.88	BASELINE
			5.487	5.546	1.08	80% SP
			5.840	5.835	-.07	60% SP
			6.277	6.494	3.34	40% SP
			6.816	6.933	1.69	20% SP
			7.481	7.548	.88	NO SP
			4.813	4.623	-4.11	MAX WT
			5.082	5.116	.67	HIGH WT
			5.759	5.935	2.96	LOW WT
			5.879	5.994	1.92	MIN WT
			5.009	5.188	3.43	V_B + 5 Kn
			4.826	5.039	4.24	V_B + 10
			4.497	4.727	4.86	V_B + 20
			4.209	4.341	3.05	V_B + 30
			5.415	5.453	.69	V_B -5
			5.646	5.706	1.23	V_B -10
			5.422	5.518	1.73	120% Fe
			5.319	5.357	.71	110% Fe
			5.077	5.109	.63	90% Fe
			4.928	4.700	-4.85	80% Fe
			5.406	5.538	2.39	HOT DAY
			4.986	4.786	-4.17	COLD DAY

Table 38.—F-111 Model-To-Simulator Correlation (Concluded)

.15

$$(\pi_1) = 9.0207 \; (\pi_2)^{-1.0490} \; (\pi_3)^{.1656-.0698\%SP} \; (\pi_4)^{8.8\Delta\rho-.1797}$$

$\bar{\pi}_2$ =			$\bar{\pi}_2$ =			
PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	CONDITION
			6.780	6.695	-1.26	BASELINE
			7.195	7.197	.03	80% SP
			7.626	7.522	-1.37	60% SP
			8.102	8.004	-1.22	40% SP
			8.643	8.569	-.87	20% SP
			9.272	9.201	-.77	NO SP
			6.226	6.474	3.83	MAX WT
			6.606	6.851	3.58	HIGH WT
			7.570	7.239	-4.58	LOW WT
			8.726	8 540	-2.13	MIN WT
			---	---	---	V_B + 5 Kn
			6.243	6.044	-3.29	V_B + 10
			5.781	5.652	-2.27	V_B + 20
			5.378	5.272	-2.01	V_B + 30
			7.079	6.919	-2.32	V_B -5
			7.409	7.142	-3.74	V_B -10
			7.089	7.229	1.94	120% Fe
			6.941	7.088	2.07	110% Fe
			6.598	6.607	.14	90% Fe
			6.388	6.194	-3.13	80% Fe
			7.372	7.346	0.35	HOT DAY
			5.895	5.864	0.53	COLD DAY

SECTION XV
WET-RUNWAY ANALYSIS CALCULATIONS

The procedure followed in Sections XII, XIII, and XIV was repeated for the data analysis of wet runway conditions and prediction equations were obtained as before. However, a velocity-dependent mu value was converted into a constant peak available mu value (independent of velocity) by using previous π_1 versus π_2 component equations, for example, equations 11, 21, and 31 in ASD-TR-77-6, Volume I, Section IX. Tables 39 through 48 illustrate the steps involved.

Table 39.—Simulator Braking Distance Results - Wet Runways (Distances in Feet)

CONDITION	B-52			KC-135			F-111		
AVAILABLE MU	.05 to .5	.05 to .4	.05 to .3	.05 to .5	.05 to .4	.05 to .3	.15 to .5	.15 to .4	.15 to .3
BASELINE	3434	4178	7922	6205	6788	7756	6652	7049	8020
80% SP	3567	---	---	6524	---	---	7169	---	---
60% SP	3635	4317	5070	6859	7675	8468	7542	8030	9124
40% SP	3796	---	---	7277	---	---	7990	---	---
20% SP	3930	4722	5327	8254	8862	9968	8720	9381	10473
NO SP	4130	4955	5729	8604	9952	11046	---	10281	11869
MAX WT	4226	4745	5261	---	9926	11182	7332	7919	8807
HIGH WT	3804	---	---	7677	---	---	6806	---	---
LOW WT	3263	---	---	4791	---	---	6982	---	---
MIN WT	3015	3481	3924	4520	4072	4854	5990	6402	7319
V_B + 5 K	3584	4266	4934	6467	6967	7871	7104	7134	8201
V_B + 10	3802	4464	5171	6740	7225	8066	7137	7416	8633
V_B + 20	4168	4884	5527	7272	8048	9233	7657	7963	9177
V_B + 30	4550	---	---	7734	---	---	8092	---	---
V_B - 5	3178	---	---	6008	6369	7330	6198	6675	7763
V_B - 10	3027	3265	4091	5719	6140	7085	5838	6414	7430
120% Fe	3598	4329	4910	6497	7353	8465	6625	7189	8286
110% Fe	3477	---	---	6298	---	---	6783	---	---
90% Fe	3356	---	---	6148	---	---	6603	---	---
80% Fe	3274	3825	4520	5975	6697	7628	5969	6679	7724
HOT DAY	3905	4721	5465	7216	8029	8750	7059	7667	8745
COLD DAY	2963	3538	4009	5278	5762	6623	5741	6234	7192

Table 40.—B-52 Pi Determination—Wet Runways

CONDITION	V	C_L	C_D	CL/CD	π_2 = .23		π_2 = .175		π_2 = .127	
					S	Sg/V^2	S	Sg/V^2	S	Sg/V^2
	FPS	--	--	π_3	FT	π_1	FT	π_1	FT	π_1
Baseline	152	.305	.321	0.950	3434	4.782	4178	5.818	4422	6.854
80% Spoilers	152	.444	.308	1.441	3567	4.967	---	---	---	---
60% Spoilers	152	.583	.295	1.974	3635	5.062	4137	6.011	5070	7.060
40% Spoilers	152	.722	.283	2.555	3796	5.286	---	---	---	---
20% Spoilers	152	.861	.270	3.191	3930	5.472	4722	6.575	5327	7.418
No Spoilers	152	1.000	.257	3.891	4130	5.751	4955	6.900	5729	7.978

Table 40.—B-52 Pi Determination—Wet Runways (Concluded)

CONDITION	V	Feo	Fe	$\frac{\rho V6}{Feg^2}$	π_2 = .23		π_2 = .175		π_2 = .127	
					S	Sg/V^2	S	Sg/V^2	S	Sg/V^2
	FPS	Lb_i	Lb_f	π_4	FT	π_1	FT	π_1	FT	π_1
Baseline	152.0	4800	3863	7341	3434	4.782	4178	5.818	4922	6.854
Max Wt	198.0*	4800	3617	38297	4226	3.468	4745	3.926	5261	4.388
High Wt	175.0*	4800	3740	17658	3804	3.996	---	---	---	---
Low Wt	139.1*	4800	3931	4237	3263	5.426	---	---	---	---
Min Wt	127.2*	4800	3995	2438	3015	5.995	3481	6.976	3924	7.827
V_B + 5	160.4*	4800	3818	10257	3584	4.482	4266	5.334	4934	6.170
V_B + 10	168.9	4800	3773	14149	3802	4.288	4464	5.034	5171	5.832
V_B + 20	185.8	4800	3683	25687	4168	3.884	4884	4.552	5527	5.151
V_B + 30	202.7	4800	3593	44392	4550	3.563	---	---	---	---
V_B - 5	143.6	5800	3908	5160	3178	4.958	---	---	---	---
V_B - 10	135.2	4800	3952	3553	3027	5.328	3625	6.380	4091	4.200
120% Fe	152.0	5760	5010	5660	3598	5.010	4329	6.028	4910	6.837
110% Fe	152.0	5280	4436	6393	3477	4.842	---	---	---	---
90% Fe	152.0	4320	3289	8623	3356	4.673	---	---	---	---
80% Fe	152.0	3840	2715	10444	3274	4.559	3825	5.326	4520	6.294
Hot Day	152.0	4800	3863	5830	3905	5.438	4721	6.574	5465	7.610
Cold Day	152.0	4800	3863	9532	2963	4.126	3538	4.927	4009	5.582

Table 41.—KC-135 Pi Determination—Wet Runways

Condition	V	C_L	C_D	C_L/C_D	π_2 = .166		π_2 = .154		π_2 = .137	
	FPS	-	-	π_3	FT	π_1	FT	π_1	FT	π_1
Baseline	209	0.310	0.202	1.535	6205	4.570	6788	5.000	7756	5.712
80% Spoilers	209	0.420	0.188	2.236	6524	4.805	---	---	---	---
60% Spoilers	209	0.530	0.174	3.063	6859	5.052	7675	5.653	8468	6.237
40% Spoilers	209	0.640	0.159	4.015	7277	5.360	---	---	---	---
20% Spoilers	209	0.750	0.145	5.165	8254	6.079	8862	6.527	9968	7.342
No Spoilers	209	0.860	0.131	6.565	8604	6.337	9952	7.330	11046	8.136

Table 41.—KC-135 Pi Determination—Wet Runways (Concluded)

Condition	V	Feo	Fe	$\frac{\rho V6}{Feo^2}$	π_2 = .166		π_2 = .154		π_2 = .137	
					S	Sg/V^2	S	Sg/V^2	S	Sg/V^2
	FPS	Lb_f	LB_f	π_4	FT	π_1	FT	π_1	Ft	π_1
Baseline	209.0	2400	1780	107688	6205	4.750	6788	5.000	7756	5.712
Max Wt	267.3	2400	1624	516319	---	---	9926	4.469	11182	5.035
High Wt	240.8	2400	1695	264483	7677	4.259	---	---	---	---
Low Wt	183.3	2400	1848	47193	4791	4.588	---	---	---	---
Min Wt	171.7 155.4	2400	1879 1922	31357 16846	4520	4.933	4072	5.425	4854	6.467
V_B + 5	217.4	2400	1757	138146	6467	4.402	6967	4.742	7871	5.358
V_B + 10	225.9	2400	1735	176161	6740	4.249	7225	4.555	8066	5.085
V_B + 20	242.8	2400	1690	248816	7272	3.969	8048	4.392	9233	5.039
V_B + 30	259.7	2400	1645	428923	7734	3.689	---	---	---	---
V_B - 5	200.6	2400	1802	82148	6008	4.803	6369	4.092	7330	5.860
V_B - 10	192.1	2400	1825	63330	5719	4.986	6140	5.353	7085	6.177
120% Fe	209.0	2880	2384	80398	6497	4.785	7353	5.420	8465	6.240
110% Fe	209.0	2640	2082	92066	6298	4.639	---	---	---	---
90% Fe	209.0	2160	1478	129705	6148	4.528	---	---	---	---
80% Fe	209.0	1920	1176	163024	5975	4.401	6697	4.932	7628	5.618
Hot Day	209.0	2400	1780	85517	7192	4.297	8029	5.914	8750	6.445
Cold Day	209.0	2400	1780	139813	5333	3.928	5762	4.244	6623	4.878

Table 42.—F-111 Pi Determination—Wet Runways

Condition	V	C_L	C_D	CL/CD	$\pi_2 = .231$		$\pi_2 = .218$		$\pi_2 = .193$	
	FPS	-	-	π_3	FT	π_1	FT	π_1	FT	π_1
Baseline	219.8	.280	.237	1.181	6652	4.430	7049	4.694	8020	5.341
80% Spoilers	219.8	.434	.218	1.987	.7169	4.774	---	---	---	---
60% Spoilers	219.8	.588	.200	2.943	7542	5.022	8030	5.347	9124	6.076
40% Spoilers	219.8	.742	.181	4.095	7990	5.321	---	---	---	---
20% Spoilers	219.8	.896	.163	5.510	8720	5.807	9381	6.247	10473	6.974
No Spoilers	219.8	1.050	.144	7.292	---	---	10281	5.846	11869	7.904

Table 42.—F-111 Pi Determination—Wet Runways (Concluded)

Condition	V	Feo	Fe	$\frac{\rho V^6}{Feg^2}$	$\pi_2 = .231$		$\pi_2 = .218$		$\pi_2 = .193$	
					S	Sg/V^2	S	Sg/V^2	S	Sg/V^2
	FPS	Lb_f	Lb_f	π_4	FT	π_1	FT	π_1	FT	π_1
Baseline	219.8	904	751	345422	6652	4.430	7094	4.694	8020	5.341
Max Wt	237.3	904	740	555118	7332	4.189	7919	4.505	8807	5.032
High Wt	2250	904	747	399186	6806	4.325	---	---	---	---
Low Wt	199.0	904	764	186981	5982	4.860	---	---	---	---
Min Wt	195.0	904	766	164990	5990	5.068	6402	5.417	7319	6.192
$V_B + 5$	228.2	904	745	435657	7104	4.389	7134	4.407	8201	5.067
$V_B + 10$	236.7	904	740	546471	7137	4.098	7416	4.258	8633	4.957
$V_B + 20$	253.6	904	729	838604	7657	3.830	7963	3.983	9177	4.591
$V_B + 30$	270.5	904	719	1250662	8092	3.558	---	---	---	---
$V_B - 5$	211.4	904	756	271498	4.462	6675	4.805	7763	5.589	
$V_B - 10$	202.9	904	761	210751	5838	4.562	6414	5.012	7430	5.806
120% Fe	219.8	1085	962	269430	6625	4.412	7189	4.787	8286	5.518
110% Fe	219.8	994	856	302906	6783	4.517	---	---	---	---
90% Fe	219.8	814	645	401820	6603	4.397	---	---	---	---
80% Fe	219.8	723	539	481120	5969	3.975	6679	4.448	7724	5.144
Hot Day	219.8	904	751	274305	7059	4.701	7667	5.106	8745	5.823
Cold Day	219.8	904	751	448468	5741	3.823	6234	4.151	7192	4.789

Table 43.—B-52 Pi Arrangement—Wet Runways

INDEPENDENT π TERM	DEPENDENT π TERM	π TERMS HELD CONSTANT		CONDITION
(π_2)	(π_1)	($\bar{\pi}_3$)	($\bar{\pi}_4$)	
.280	3.068	.95	.7341	BASELINE
.270	3.278			
.260	3.678			
.230	4.782			
.225	5.064			
.22	5.198			
-	-			
-	-			
-	-			
-	-			
-	-			
-	-			

(π_3)	(π_1)	($\bar{\pi}_2$)	($\bar{\pi}_4$)	CONDITION
0.950	4.782	.23	.7341	BASELINE
1.441	4.967			80% SPOILERS
1.974	5.062			60% SPOILERS
2.555	5.286			40% SPOILERS
3.191	5.472			20% SPOILERS
3.891	5.751			NO SPOILERS

Table 43.—B-52 Pi Arrangement—Wet Runways (Continued)

INDEPENDENT π TERM	DEPENDENT π TERM	π TERMS HELD CONSTANT		
(π_4)	(π_1)	$\bar{\pi}_2$	$\bar{\pi}_3$	CONDITION
7341	4.782	0.23	0.95	BASELINE
38297	3.468			MAX WT
17658	3.996			HIGH WT
4237	5.426			LOW WT
2438	5.995			MIN WT
10257	4.482			V_B + 5
14149	4.288			V_B + 10
25687	3.884			V_B + 20
44392	3.563			V_B + 30
5160	4.958			V_B -5
3553	5.328			V_B -10
5660	5.010			120% Fe
6393	4.842			110% Fe
8623	4.673			90% Fe
10444	4.559			80% Fe
5830	5.438			HOT DAY
9532	4.126			COLD DAY

Table 43.—B-52 Pi Arrangement—Wet Runways (Continued)

INDEPENDENT π TERM	DEPENDENT π TERM	π TERMS HELD CONSTANT		CONDITION
(π_2)	(π_1)	($\bar{\pi}_3$)	($\bar{\pi}_4$)	
.225	5.064	.95	.7341	BASELINE
.200	5.436			
.175	5.818			
.150	6.174			
.127	6.854			
.100	7.929			
.090	8.344			
.080	8.780			
.070	9.449			
.06	10.030			
.05	10.903			
---	---			

(π_3)	(π_1)	($\bar{\pi}_2$)	($\bar{\pi}_4$)	CONDITION
0.950	5.818	.175	.7341	BASELINE
---	---			80% SPOILERS
1.974	6.011			60% SPOILERS
---	---			40% SPOILERS
3.191	6.575			20% SPOILERS
3.891	6.900			NO SPOILERS

Table 43.—B-52 Pi Arrangement—Wet Runways (Continued)

INDEPENDENT π TERM	DEPENDENT π TERM	π TERMS HELD CONSTANT		
(π_4)	(π_1)	$\bar{\pi}_2$	$\bar{\pi}_3$	CONDITION
7341	5.818	.175	.95	BASELINE
37334	3.926			MAX WT
---	---			HIGH WT
---	---			LOW WT
2380	6.976			MIN WT
10257	5.334			V_B + 5
14149	5.034			V_B + 10
25687	4.552			V_B + 20
---	---			V_B + 30
---	---			V_B -5
3553	6.380			V_B -10
5660	6.028			120% Fe
---	---			110% Fe
---	---			90% Fe
10444	5.326			80% Fe
5830	6.574			HOT DAY
9532	4.927			COLD DAY

Table 43.—B-52 Pi Arrangement—Wet Runways (Continued)

INDEPENDENT π TERM	DEPENDENT π TERM	π TERMS HELD CONSTANT		CONDITION
(π_2)	(π_1)	$(\bar{\pi}_3)$	$(\bar{\pi}_4)$	
.225	5.064	.95	7341	BASELINE
.200	5.436			
.175	5.818			
.150	6.174			
.127	6.854			
.100	7.929			
.090	8.344			
.080	8.780			
.070	9.449			
.060	10.030			
.050	10.903			
---	---			

(π_3)	(π_1)	$(\bar{\pi}_2)$	$(\bar{\pi}_4)$	CONDITION
.95	6.854	.127	7341	BASELINE
---	---			80% SPOILERS
1.974	7.060			60% SPOILERS
---	---			40% SPOILERS
3.191	7.418			20% SPOILERS
3.891	7.978			NO SPOILERS

Table 43.—B-52 Pi Arrangement—Wet Runways (Concluded)

INDEPENDENT π TERM	DEPENDENT π TERM	π TERMS HELD CONSTANT		
(π_4)	(π_1)	$\bar{\pi}_2$	$\bar{\pi}_3$	CONDITION
7341	6.854	.127	.95	BASELINE
37334	4.388			MAX WT
---	---			HIGH WT
---	---			LOW WT
2380	7.827			MIN WT
10257	6.170			V_B + 5
14149	5.832			V_B + 10
25687	5.151			V_B + 20
---	---			V_B + 30
---	---			V_B -5
3553	7.200			V_B -10
5660	6.837			120% Fe
---	---			110% Fe
---	---			90% Fe
10444	6.294			80% Fe
5830	7.610			HOT DAY
9532	5.582			COLD DAY

Table 44.—KC-135 Pi Arrangement—Wet Runways

INDEPENDENT π TERM	DEPENDENT π TERM	π TERMS HELD CONSTANT		CONDITION
(π_2)	(π_1)	($\bar{\pi}_3$)	($\bar{\pi}_4$)	
.60	---	1.535	107688	BASELINE
.55	---			
.50	---			
.166	4.570			
.275	2 527			
.250	2.861			
.200	3.782			
.150	5.216			
.125	6.337			
.100	8.017			
.137	5.712			
.154	5.000			

(π_3)	(π_1)	($\bar{\pi}_2$)	($\bar{\pi}_4$)	CONDITION
1.535	4.570	1.66	.107688	BASELINE
2.236	4.805			80% SPOILERS
3.053	5.052			60% SPOILERS
4.015	5.360			40% SPOILERS
5.165	6.079			20% SPOILERS
6.565	6.337			NO SPOILERS

Table 44.—KC-135 Pi Arrangement—Wet Runways (Continued)

INDEPENDENT π TERM	DEPENDENT π TERM	π TERMS HELD CONSTANT		
(π_4)	(π_1)	$\bar{\pi}_2$	$\bar{\pi}_3$	CONDITION
107688	4,570	.166	1.535	BASELINE
516319	- -			MAX WT
264483	4.259			HIGH WT
47193	4.588			LOW WT
31357	4.933			MIN WT
138146	4.402			V_B + 5
176161	4.249			V_B + 10
278816	3.969			V_B + 20
428923	3.689			V_B + 30
83148	4.803			V_B -5
63330	4.896			V_B -10
80398	4.785			120% Fe
92066	4.639			110% Fe
129706	4.528			90% Fe
163024	4.401			80% Fe
85517	5.297			HOT DAY
139813	3.928			COLD DAY

Table 44.—KC-135 Pi Arrangement—Wet Runways (Continued)

INDEPENDENT π TERM	DEPENDENT π TERM	π TERMS HELD CONSTANT		CONDITION
(π_2)	(π_1)	$(\bar{\pi}_3)$	$(\bar{\pi}_4)$	
.60	- -	1.535	.107688	BASELINE
.55	- -			
.50	- -			
.154	5.000			
.275	2.527			
.250	2.861			
.200	3.762			
.150	5.216			
.125	6.337			
.100	8.017			
.137	5.712			
.166	4.570			

(π_3)	(π_1)	$(\bar{\pi}_2)$	$(\bar{\pi}_4)$	CONDITION
1.535	5.000	.154	.107688	BASELINE
- -	- -			80% SPOILERS
3.053	5.653			60% SPOILERS
- -	- -			40% SPOILERS
5.165	6.527			20% SPOILERS
6.565	7.330			NO SPOILERS

Table 44.–KC-135 Pi Arrangement–Wet Runways (Continued)

INDEPENDENT π TERM (π_4)	DEPENDENT π TERM (π_1)	π TERMS HELD CONSTANT $\bar{\pi}_2$	$\bar{\pi}_3$	CONDITION
107688	5.000	.154	1.535	BASELINE
516319	4.469			MAX WT
- -	- -			HIGH WT
- -	- -			LOW WT
16846	5.425			MIN WT
138146	4.742			V_B + 5
176161	4.555			V_B + 10
278816	4.392			V_B + 20
- -	- -			V_B + 30
83148	5.092			V_B -5
63330	5.353			V_B -10
80398	5.420			120% Fe
- -	- -			110% Fe
- -	- -			90% Fe
163105	4.932			80% Fe
85517	5.914			HOT DAY
139813	4.244			COLD DAY

Table 44.—KC-135 Pi Arrangement—Wet Runways (Continued)

INDEPENDENT π TERM	DEPENDENT π TERM	π TERMS HELD CONSTANT		CONDITION
(π_2)	(π_1)	$(\bar{\pi}_3)$	$(\bar{\pi}_4)$	
.60	- -	1.535	.107683	BASELINE
.55	- -			
.50	- -			
.137	5.712			
.275	2.527			
.250	2.861			
.200	3.762			
.150	5.216			
.125	6.337			
.100	8.017			
.154	5.000			
.166	4.570			

(π_3)	(π_1)	$(\bar{\pi}_2)$	$(\bar{\pi}_4)$	CONDITION
1.535	5.712	.137	.107688	BASELINE
1.535	5.712			80% SPOILERS
- -	- -			60% SPOILERS
3.053	6.237			40% SPOILERS
- -	- -			20% SPOILERS
6.565	8.136			NO SPOILERS

Table 44.—KC-135 Pi Arrangement—Wet Runways (Concluded)

INDEPENDENT π TERM	DEPENDENT π TERM	π TERMS HELD CONSTANT		
(π_4)	(π_1)	$\bar{\pi}_2$	$\bar{\pi}_3$	CONDITION
107688	5.712	.137	1.535	BASELINE
516319	5.035			MAX WT
- -	- -			HIGH WT
- -	- -			LOW WT
16846	6.467			MIN WT
138146	5.358			V_B + 5
176161	5.085			V_B + 10
278816	5.039			V_B + 20
- -	- -			V_B + 30
83148	5.860			V_B -5
63330	6.177			V_B -10
80398	6.240			120% Fe
- -	- -			110% Fe
- -	- -			90% Fe
163024	5.618			80% Fe
85517	6.445			HOT DAY
139813	4.878			COLD DAY

Table 45.—F-111 Pi Arrangement—Wet Runways

INDEPENDENT π TERM (π_2)	DEPENDENT π TERM (π_1)	π TERMS HELD CONSTANT ($\bar{\pi}_3$)	($\bar{\pi}_4$)	CONDITION
.300	3.234	1.181	345422	BASELINE
.275	3.595			
.200	3.849			
.250	4.205			
.240	4.237			
.230	4.457			
.220	4.679			
.210	4.889			
.200	5.305			
.190	5.405			
.175	5.827			
.150	6.695			

(π_3)	(π_1)	($\bar{\pi}_2$)	($\bar{\pi}_4$)	CONDITION
1.181	4.430	.231	345422	BASELINE
1.987	4.744			80% SPOILERS
2.943	5.022			60% SPOILERS
4.095	5.321			40% SPOILERS
5.510	5.807			20% SPOILERS
7.292	- -			NO SPOILERS

Table 45.—F-111 Pi Arrangement—Wet Runways (Continued)

INDEPENDENT π TERM (π_4)	DEPENDENT π TERM (π_1)	π TERMS HELD CONSTANT $\bar{\pi}_2$	$\bar{\pi}_3$	CONDITION
345422	4.430	.231	1.181	BASELINE
555118	4.189			MAX WT
399186	4.325			HIGH WT
186981	4.860			LOW WT
164990	5.068			MIN WT
435657	4.389			V_B + 5
546471	4.098			V_B + 10
838604	3.830			V_B + 20
1250662	3.558			V_B + 30
271498	4.462			V_B -5
210751	4.562			V_B -10
269430	4.412			120% Fe
302907	4.517			110% Fe
401820	4.397			90% Fe
481120	3.975			80% Fe
274305	4.701			HOT DAY
448468	3.823			COLD DAY

Table 45.—F-111 Pi Arrangement—Wet Runways (Continued)

INDEPENDENT π TERM	DEPENDENT π TERM	π TERMS HELD CONSTANT		CONDITION
(π_2)	(π_1)	$(\bar{\pi}_3)$	$(\bar{\pi}_4)$	
.300	3.234	1.181	345422	BASELINE
.275	3.595			
.260	3.849			
.250	4.205			
.240	4.337			
.230	4.457			
.220	4.679			
.210	4.889			
.200	5.305			
.190	5.405			
.175	5.827			
.150	6.695			

(π_3)	(π_1)	$(\bar{\pi}_2)$	$(\bar{\pi}_4)$	CONDITION
1.181	4.694	.218	345422	BASELINE
1.987	- -			80% SPOILERS
2.943	5.347			60% SPOILERS
4.095	- -			40% SPOILERS
5.510	6.247			20% SPOILERS
7.292	6.846			NO SPOILERS

Table 45.—F-111 Pi Arrangement—Wet Runways (Continued)

INDEPENDENT π TERM (π_4)	DEPENDENT π TERM (π_1)	π TERMS HELD CONSTANT $\bar{\pi}_2$	$\bar{\pi}_3$	CONDITION
345422	4.694	.218	1.181	BASELINE
555118	4.505			MAX WT
399186	- -			HIGH WT
186981	- -			LOW WT
164990	5.417			MIN WT
435657	4.407			V_B + 5
546471	4.258			V_B + 10
838604	3.983			V_B + 20
1250662	- -			V_B + 30
271498	4.805			V_B -5
210751	5.012			V_B -10
269430	4.787			120% Fe
302907	- -			110% Fe
401820	- -			90% Fe
481120	4.448			80% Fe
274305	5.106			HOT DAY
448468	4.151			COLD DAY

Table 45.—F-111 Pi Arrangement—Wet Runways (Continued)

INDEPENDENT π TERM	DEPENDENT π TERM	π TERMS HELD CONSTANT		CONDITION
(π_2)	(π_1)	$(\bar{\pi}_3)$	$(\bar{\pi}_4)$	
.300	3.234	1.181	345422	BASELINE
.275	3.595			
.260	3.849			
.250	4.205			
.240	4.237			
.230	4.457			
.220	4.679			
.210	4.889			
.200	5.305			
.190	5.405			
.175	5.827			
.150	6.695			

(π_3)	(π_1)	$(\bar{\pi}_2)$	$(\bar{\pi}_4)$	CONDITION
1.181	5.341	.193	345422	BASELINE
1.987	- -			80% SPOILERS
2.943	6.076			60% SPOILERS
4.095	- -			40% SPOILERS
5.510	6.974			20% SPOILERS
7.292	7.904			NO SPOILERS

Table 45.—F-111 Pi Arrangement—Wet Runways (Concluded)

INDEPENDENT π TERM	DEPENDENT π TERM	π TERMS HELD CONSTANT		
(π_4)	(π_1)	$\bar{\pi}_2$	$\bar{\pi}_3$	CONDITION
345422	5.341	.193	1.181	BASELINE
555118	5.032			MAX WT
399186	- -			HIGH WT
186981	- -			LOW WT
164990	6.192			MIN WT
435657	5.067			V_B + 5
546471	4.957			V_B + 10
838604	4.591			V_B + 20
1250662	- -			V_B + 30
271498	5.589			V_B -5
210751	5.806			V_B -10
269430	5.518			120% Fe
302907	- -			110% Fe
401820	- -			90% Fe
481120	5.144			80% Fe
274305	5.823			HOT DAY
448468	4.789			COLD DAY

Table 46.—B-52 Model-To-Simulator Correlation—Wet Runways

$$(\pi_1)^{.175} = 13.46155\,(\pi_2)^{-.5188}\,(\pi_3)^{.12743-.12585\%SP}\,(\pi_4)^{19.6\Delta\rho-.1991}$$

$\bar{\pi}_2$ =			$\bar{\pi}_2$ =			
PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	CONDITION
5.657	5.818	2.76	6.673	6.854	2.64	BASELINE
- -	- -	- -	- -	- -	- -	80% SP
5.862	6.011	2.49	6.914	7.060	2.07	60% SP
- -	- -	- -	- -	- -	- -	40% SP
6.371	6.575	3.10	7.516	7.418	-1.32	20% SP
6.728	6.900	2.48	7.936	7.978	0.52	NO SP
4.092	3.926	-4.25	4.852	4.388	-10.57*	MAX WT
- -	- -	- -	- -	- -	- -	HIGH WT
- -	- -	- -	- -	- -	- -	LOW WT
7.080	6.976	-1.48	8.327	7.827	-6.39*	MIN WT
5.293	5.334	0.78	6.243	6.170	-1.19*	V_B + 5 Kn
4.964	5.034	1.39	5.856	5.832	- .42	V_B + 10
4.409	4.552	3.14	5.200	5.151	- .96	V_B + 20
- -	- -	- -	- -	- -	- -	V_B + 30
- -	- -	- -	- -	- -	- -	V_B -5
6.537	6.380	-2.45	7.710	7.200	7.08*	V_B -10
5.958	6.028	1.16	7.028	6.837	-2.79	120% Fe
- -	- -	- -	- -	- -	-	110% Fe
- -	- -	- -	- -	- -	- -	90% Fe
5.274	5.326	0.98	6.221	6.294	1.16	80% Fe
6.437	6.574	2.08	7.593	7.610	0.22	HOT DAY
4.727	4.927	4.05	5.577	5.582	0.09	COLD DAY

Table 46.—B-52 Model-To-Simulator Correlation—Wet Runways (Concluded)

$$(\pi_1) = 13.42178\,(\pi_2)^{.127}\;(\pi_3)^{-.5188}\;(\pi_4)^{.10492-.12427\%SP}\quad 20.97\Delta\rho-.197884$$

$\bar{\pi}_2$ =			$\bar{\pi}_2$ =			
PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	CONDITION
6.733	6.854	1.76	5.708	5.818	1.88	BASELINE
- -	- -	- -	- -	- -	- -	80% SP
6.867	7.060	2.74	5.821	6.011	3.16	60% SP
- -	-	- -	- -	- -	- -	40% SP
7.381	7.418	0.49	6.258	6.575	4.83	20% SP
7.757	7.978	2.76	6.576	6.900	4.69	NO SP
4.905	4.388	-11.78*	4.137	3.926	-5.40*	MAX WT
- -	- -	- -	- -	- -	- -	HIGH WT
- -	- -	- -	- -	- -	- -	LOW WT
8.391	7.827	-7.20*	7.134	6.976	-2.26	MIN WT
6.302	6.170	-2.14	5.343	5.334	.15	V_B + 5 Kn
5.913	5.83[illegible]	-1.40	5.013	5.034	.42	V_B + 10
5.255	5.151	-2.02	4.455	4.552	2.12	V_B + 20
- -	- -	- -	- -	- -	- -	V_B + 30
- -	- -	- -	- -	- -	- -	V_B -5
7.773	7.200	-7.95*	6.590	6.380	-3.28	V_B -10
7.089	6.837	-3.68	6.010	6.028	.31	120% Fe
- -	- -	- -	- -	- -	- -	110% Fe
- -	- -	- -	- -	- -	- -	90% Fe
6.280	6.294	0.23	5.324	5.326	.05	80% Fe
7.699	7.610	-1.17	6.524	6.574	.76	HOT DAY
5.575	5.582	0.13	4.724	4.927	4.12	COLD DAY

Table 47.—KC-135 Model-To-Simulator Correlation—Wet Runways

$$(\pi_1) = 1.9123\,(\pi_2)^{.166} - 1.1410\,(\pi_3)^{1995-.1225\%SP}\,(\pi_4)^{18\Delta\rho} - .106286$$

$\bar{\pi}_2$ = .166			$\bar{\pi}_2$ = .154			$\bar{\pi}_2$ = .137			
PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	CONDITION
4.476	4.570	2.06	4.894	5.000	2.11	5.591	5.712	2.13	BASELINE
4.699	4.805	2.20	- -	- -	- -	- -	- -	- -	80% SP
4.985	5.052	1.33	5.451	5.653	3.58	6.226	6.237	0.17	60% SP
5.339	5.360	.39	- -	- -	- -	- -	- -	- -	40% SP
5.773	6.079	5.04	6.312	6.527	3.30	7.210	7.342	1.79	20% SP
6.304	6.337	.52	6.893	7.330	5.96*	7.874	8.136	3.21	NO SP
- -	- -	- -	4.143	4.469	7.30*	4.733	5.035	6.00*	MAX WT
4.068	4.259	4.49	- -	- -	- -	- -	- -	- -	HIGH WT
4.886	4.588	-6.51*	- -	- -	- -	- -	- -	- -	LOW WT
5.103	4.933	-3.46	5.961	5.425	-9.88*	6.809	6.467	-5.30	MIN WT
4.359	4.402	.98	4.766	4.742	-0.50	5.445	5.358	-1.62	V_B + 5 Kn
4.258	4.249	.03	4.645	4.555	-1.97	5.306	5.085	-4.34	V_B + 10
4.046	3.969	-1.94	4.424	4.392	-0.72	5.053	5.039	-.29	V_B + 20
3.865	3.689	-4.75	- -	- -	- -	- -	- -	- -	V_B + 30
4.601	4.803	4.22	5.031	5.092	1.21	5.747	5.860	1.94	V_B - 5
4.736	4.986	5.01	5.173	5.353	3.26	5.915	6.177	4.231	V_B - 10
4.617	4.785	3.51							120% Fe
4.551	4.639	1.88	- -	- -	- -	- -	- -	- -	110% Fe
4.388	4.528	3.09	- -	- -	- -	- -	- -	- -	90% Fe
4.283	4.401	2.67	4.683	4.932	5.06	5.350	5.618	4.78	80% Fe
5.071	5.297	4.27		5.914					HOT DAY
3.742	3.928	4.73	.154	4.244		.137			COLD DAY

Table 47.—KC-135 Model-To-Simulator Correlation—Wet Runways (Continued)

$$(\pi_1) = 1.2841\,(\pi_2)^{-1.410}\,(\pi_3)^{.2161-.1412\%SP}\,(\pi_4)^{21.0\Delta\rho\,-.07158}$$

$\bar{\pi}_2$ = .154			$\bar{\pi}_2$ =			$\bar{\pi}_2$ = .154			
PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	CONDITION
4.909	5.000	1.81	5.603	5.712	1.83	4.490	4.570	1.76	BASELINE
- -	- -	- -	- -	- -	- -	4.724	4.805	1.68	80% SP
5.505	5.653	2.61	6.289	6.237	-0.83	5.035	5.052	0.34	60% SP
- -	- -	- -	- -	- -	- -	5.428	5.360	-1.28	40% SP
6.472	6.527	0.84	7.394	7.342	-0.71	5.919	6.079	2.63	20% SP
7.140	7.330	2.59	8.156	8.136	-0.25	6.530	6.337	-3.04	NO SP
4.388	4.469	-1.82	5.013	5.035	0.44	- -	- -	- -	MAX WT
- -	- -	- -	- -	- -	- -	4.210	4.259	1.16	HIGH WT
- -	- -	- -	- -	- -	- -	4.763	4.588	-3.82	LOW WT
5.606	5.425	-3.34	6.404	6.467	0.96	4.904	4.933	0.58	MIN WT
4.822	4.742	-1.68	5.509	5.358	-2.82	4.410	4.402	-.18	V_B + 5 Kn
4.739	4.555	-4.04	5.414	5.085	-6.46*	4.334	4.249	-2.00	V_B + 10
4.586	4.392	-4.41	5.239	5.039	-3.97	4.194	3.969	-5.68*	V_B + 20
- -	- -	- -	- -	- -	- -	4.067	4.689	-10.23*	V_B + 30
5.001	5.092	1.79	5.713	5.860	2.52	4.573	4.803	4.79	V_B - 5
5.099	5.353	4.74	5.825	6.177	5.69*	4.663	4.986	6.47*	V_B - 10
						4.585	4.785	4.19	120% Fe
- -	- -	- -	- -	- -	- -	4.540	4.639	2.12	110% Fe
- -	- -	- -	- -	- -	- -	4.430	4.528	2.16	90% Fe
4.765	4.932	3.39	5.444	5.618	3.10	4.358	4.401	0.96	80% Fe
5.584	5.914	5.58					5.297		HOT DAY
4.020	4.244	5.28	.137				3.928		COLD DAY

Table 47.—KC-135 Model-To-Simulator Correlation—Wet Runways (Concluded)

$$(\pi_1)^{.137} = 1.5899\,(\pi_2)^{-1.410}\,(\pi_3)^{.1913-.1781\%SP}\,(\pi_4)^{17.54\Delta\rho}\;.087969$$

$\bar{\pi}_2$ = .137			$\bar{\pi}_2$ =			$\bar{\pi}_2$ = .137			
PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	CONDITION
5.592	5.712	2.10	4.896	5.000	2.08	4.477	4.570	2.03	BASELINE
- -	- -	- -	- -	- -	- -	4.630	4.805	3.63	80% SP
6.111	6.237	2.02	5.349	5.653	5.37	4.892	5.052	3.16	60% SP
- -	- -	- -	- -	- -	- -	5.261	5.360	1.85	40% SP
7.181	7.342	2.19	6.286	6.527	3.69	5.749	6.079	5.44*	20% SP
7.7971	8.136	2.03	6.977	7.330	4.81	6.381	6.337	-.70	NO SP
4.872	5.035	3.23	4.265	4.469	4.57	- -	- -	-	MAX WT
- -	- -	- -	- -	- -	- -	4.137	4.259	2.88	HIGH WT
- -	- -	- -	- -	- -	- -	4.814	4.588	-4.94	LOW WT
6.584	6.467	-1.81	5.763	5.425	-.624	4.990	4.933	-1.17	MIN WT
5.471	5.358	-2.12	4.789	4.742	-0.99	4.380	4.402	.50	V_B + 5 Kn
5.35	5.085	-5.32	4.688	4.555	-2.92	4.287	4.249	-.90	V_B + 10
5.14	5.039	-2.08	4.503	4.392	-2.51	4.118	3.969	-3.76	V_B + 20
- -	- -	- -	- -	- -	- -	3.965	3.689	-7.46*	V_B + 30
5.721	5.860	2.37	5.008	5.092	1.65	4.580	4.803	4.65	V_B - 5
5.860	6.177	5.13	5.130	5.353	4.17	4.691	4.986	5.91*	V_B - 10
						4.594	4.785	4.00	120% Fe
- -	- -	- -	- -	- -	- -	4.539	4.639	2.14	110% Fe
- -	- -	- -	- -	- -	- -	4.405	4.528	2.73	90% Fe
5.392	5.618	4.024	4.720	4.932	4.31	4.317	4.401	1.91	80% Fe
6.282	6.445	2.53							HOT DAY
4.708	4.878	3.48							COLD DAY

Table 48.—F-111 Model-To-Simulator Correlation—Wet Runways

.231

$(\pi_1) = 7.1987\ (\pi_2)$ -1.0490 (π_3) .1790-.0834%SP (π_4) 8.0Δρ-.1606

$\bar{\pi}_2$ =			$\bar{\pi}_2$ = .231			$\bar{\pi}_2$ = .231			
PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	CONDITION
4.388	4.430	.94	4.663	4.694	.66	5.299	5.341	.79	BASELINE
4.665	4.774	2.28	- -	- -	- -	- -	- -	- -	80% SP
4.964	5.022	1.16	5.275	[illegible]	1.36	5.994	6.076	1.35	60% SP
5.303	5.321	.33	- -	- -	- -	- -	- -	- -	40% SP
5.697	5.807	1.38	6.054	6.247	3.08	6.879	6.974	1.36	20% SP
- -	- -	- -	6.549	6.846	4.34	7.442	7.904	5.84	NO SP
4.066	4.189	2.93	4.312	4.505	4.29	4.910	5.032	2.42	MAX WT
4.287	4.325	.87	- -	- -	- -	- -	- -	- -	HIGH WT
4.843	4.860	.35	- -	- -	- -	- -	- -	- -	LOW WT
4.941	5.068	2.50	5.251	5.417	3.06	5.966	6.192	3.65	MIN WT
4.228	4.389	3.67	4.492	4.407	-1.93	5.105	5.067	-.75	V_B + 5 Kn
4.077	4.098	.53	4.332	4.258	-1.73	4.922	4.957	.70	V_B + 10
3.806	3.830	.65	4.044	3.983	-1.52	4.595	4.591	--.10	V_B + 20
3.568	3.558	-.28	- -	- -	- -	- -	- -	- -	V_B + 30
4.561	4.462	-2.23	4.847	4.805	-.87	5.508	5.589	1.45	V_B - 5
4.751	4.562	-4.13	5.048	5.012	-.71	5.736	5.806	1.21	V_B - 10
4.567	4.412	-3.52	4.853	4.787	-1.37	5.514	5.518	.06	120% Fe
4.482	4.517	.78	- -	- -	- -	- -	- -	- -	110% Fe
4.283	4.397	2.60	- -	- -	- -	- -	- -	- -	90% Fe
4.161	3.975	-4.68	4.421	4.448	.59	5.024	5.144	2.32	80% Fe
4.726	4.701	.53	5.022	5.106	1.64	5.707	5.823	1.99	HOT DAY
3.860	3.823	.98	4.102	4.151	1.18	4.661	4.789	2.67	COLD DAY

Table 48.—F-111 Model-To-Simulator Correlation—Wet Runways (Continued)

.218

$(\pi_1) = 9.3019\,(\pi_2)^{-1.0490}\,(\pi_3)^{.1976-.1046\%SP}\,(\pi_4)^{7.75\Delta p\,-.1804}$

π_2 =			$\bar{\pi}_2$ =			$\bar{\pi}_2$ =			
PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	CONDITION
4.679	4.694	.33	4.403	4.430	.60	5.316	5.341	0.45	BASELINE
- -	- -	- -	4.688	4.774	1.80	- -	- -	- -	80% SP
5.329	5.347	.35	5.015	5.022	.16	5.055	6.076	0.34	60% SP
- -	- -	- -	5.400	5.321	-1.49	- -	- -	- -	40% SP
6.228	6.247	.30	5.861	5.807	-.94	7.077	6.974	-1.48	20% SP
6.822	6.846	.35	- -	- -	- -	7.751	7.904	1.92	NO SP
4.285	4.505	4.89	4.042	4.189	3.51	4.880	5.032	3.01	MAX WT
- -	- -	- -	4.290	4.325	.82	- -	- -	- -	HIGH WT
- -	- -	- -	4.918	4.860	-1.21	- -	- -	- -	LOW WT
5.346	5.417	1.30	5.031	5.068	.73	6.074	6.192	1.90	MIN WT
4.487	4.407	-1.80	4.222	4.399	3.79	5.098	5.067	-0.63	V_B + 5 Kn
4.307	4.258	-1.14	4.053	4.098	1.10	4.894	4.957	1.27	V_B + 10
3.987	3.983	-.09	3.752	3.830	2.05	4.530	4.591	1.32	V_B + 20
- -	- -	- -	3.490	3.558	1.92	- -	- -	- -	V_B + 30
4.886	4.805	-1.69	4.598	4.462	-3.06	5.552	5.589	0.64	V_B - 5
5.115	5.012	-2.05	4.813	4.552	-5.50*	5.812	5.806	-0.10	V_B - 10
4.893	4.787	-2.21	4.605	4.412	-4.37	5.560	5.518	-0.77	120% Fe
- -	- -	- -	4.508	4.517	.19	- -	- -	- -	110% Fe
- -	- -	- -	4.84	4.397	2.56	- -	- -	- -	90% Fe
4.407	4.448	.91	4.147	3.975	-4.34	5.008	5.144	2.64	80% Fe
5.115	5.106	.18	4.814	4.701	2.40	5.812	5.823	0.19	HOT DAY
4.155	4.151	.09	3.909	3.823	2.25	4.721	4.789	1.42	COLD DAY

Table 48.—F-111 Model-To-Simulator Correlation—Wet Runways (Concluded)

.193u

(π_1) = 9.6663 (π_2) -1.0490 (π_3) .1973-.1296%SP (π_4) 6.85Δp -.1827

π_2 = 193μ			π_2 =			π_2 = 193μ			
PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	PREDICTED (π_1)	ACTUAL (π_1)	% ERROR	CONDITION
5.342	5.341	-.02	4.424	4.430	.13	4.701	4.694	- .15	BASELINE
- -	- -	- -	4.665	4.774	2.28	- -	- -	- -	80% SP
6.009	6.076	1.09	4.977	5.022	.90	5.289	5.347	1.10	60% SP
- -	- -	- -	5.370	5.321	-.93	- -	- -	- -	40% SP
7.076	6.974	-1.47	5.861	5.807	-.93	6.228	6.247	0.31	20% SP
7.817	7.[illegible]	[illegible]	- -	- -	- -	6.879	6.846	-0.48	NO SP
4.898	5.032	2.65	4.057	4.139	3.16	4.301	4.505	4.54	MAX WT
- -	- -	- -	4.309	4.325	.38	- -	- -	- -	HIGH WT
- -	- -	- -	4.949	4.860	-1.84	- -	- -	- -	LOW WT
6.114	6.192	1.27	5.063	5.068	.09	5.381	5.417	0.66	MIN WT
5.120	5.067	-1.06	4.240	4.389	3.38	4.506	4.407	-2.24	V_B + 5 Kn
4.912	4.957	.90	4.068	4.098	.73	4.323	4.258	-1.52	V_B + 10
4.543	4.591	1.05	3.762	3.830	1.78	3.998	3.983	-0.36	V_B + 20
- -	- -	- -	3.496	3.558	1.74	- -	- -	- -	V_B + 30
5.582	5.5[illegible]	.11	4.623	4.462	-3.61	4.913	4.805	-2.23	V_B - 5
5.847	5.806	-.69	4.042	4.[illegible]62	-6.13*	5.145	5.012	-2.65	V_B - 10
5.590	5.518	-1.31	4.629	4.412	-4.94	4.920	4.787	-2.76	120% Fe
- -	- -	- -	4.531	4.51[illegible]	-.32	- -	- -	- -	110% Fe
- -	- -	- -	4.303	4.397	2.13	- -	- -	- -	90% Fe
5.028	5.144	2.25	4.[illegible]	3.875	-4.76	4.425	4.448	0.51	80% Fe
5.811	5.823	0.20	4.812	4.701	2.36	5.113	5.106	0.14	HOT DAY
4.781	4.789	0.17	3.960	3.823	3.58	4.207	4.151	1.35	COLD DAY